SECTION 23 00 00

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS
01/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 201	(2002) Fans and Systems
AMCA 210	(1999; 2001a) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(2005) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(2005) Methods for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA 500-D	(1998) Laboratory Methods of Testing Dampers for Rating

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 260	(2001; Addendum 2002) Sound Rating of Ducted Air Moving and Conditioning Equipment
ARI 410	(2001; 2002a) Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
ARI 430	(1999) Standard for Central-Station Air-Handling Units
ARI 880	(1998; 2002a) Standard for Air Terminals
ARI 885	(1998; 2002a) Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets
ARI DCAACP	(Online) Directory of Certified Applied Air-Conditioning Products
ARI Guideline D	(1996) Application and Installation of Central Station Air-Handling Units

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(1990; R 1999) Load Ratings and Fatigue Life for Roller Bearings
ABMA 9	(1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15	(2007; Errata 2007) Safety Code for Refrigeration
ASHRAE 52.2	(2007; Addenda B 2008) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62.1	(2007; INT 2007; INT 2-15 2008; Errata 2008; Addenda a, b, e, f and h 2008) Ventilation for Acceptable Indoor Air Quality
ASHRAE 68	(1997) Laboratory Method of Testing to Determine the Sound Power In a Duct
ASHRAE 70	(2006) Method of Testing for Rating the Performance of Air Outlets and Inlets
ASHRAE 90.1 - IP	(2007; Errata 2008; Errata 2008; Errata 2008) Energy Standard for Buildings Except Low-Rise Residential Buildings, I-P Edition

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2008) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 167	(1999; R 2004) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 53/A 53M	(2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 924/A 924M	(2007) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B 117	(2007a) Standing Practice for Operating Salt Spray (Fog) Apparatus
ASTM B 152/B 152M	(2006a) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B 209	(2007) Standard Specification for Aluminum

	and Aluminum-Alloy Sheet and Plate
ASTM C 1071	(2005) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM C 553	(2002) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C 916	(1985; R 2001e1) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM D 1654	(2005) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 3359	(2002) Measuring Adhesion by Tape Test
ASTM D 520	(2000; R 2005) Zinc Dust Pigment
ASTM E 2016	(2006) Standard Specification for Industrial Woven Wire Cloth
ASTM E 84	(2008a) Standard Test Method for Surface Burning Characteristics of Building Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2006) Standard for Industrial Controls and Systems Enclosures
NEMA MG 1	(2007) Standard for Motors and Generators
NEMA MG 10	(2001; R 2007) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2007) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2007; AMD 1 2008) National Electrical Code - 2008 Edition
NFPA 701	(2004) Fire Tests for Flame Propagation of Textiles and Films
NFPA 90A	(2008) Standard for the Installation of Air Conditioning and Ventilating Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA FGDCS	(2003, 7th Ed) Fibrous Glass Duct Construction Standards

SMACNA HVAC Duct Const Stds	(1995; Addendum 1997, 2nd Ed) HVAC Duct Construction Standards - Metal and Flexible
SMACNA Install Fire Damp HVAC	(2002, 5th Ed) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
SMACNA Leakage Test Mnl	(1985, 1st Ed) HVAC Air Duct Leakage Test Manual

UNDERWRITERS LABORATORIES (UL)

UL 181	(2005) Standard for Factory-Made Air Ducts and Air Connectors
UL 555	(2006) Standard for Fire Dampers
UL 555S	(1999; Rev thru Jul 2006) Smoke Dampers
UL 586	(1996; Rev thru Aug 2008) Standard for High-Efficiency Particulate, Air Filter Units
UL 705	(2004; Rev thru Mar 2006) Standard for Power Ventilators
UL 723	(2008) Standard for Test for Surface Burning Characteristics of Building Materials
UL 746C	(2004; Rev thru Feb 2006) Polymeric Materials - Use in Electrical Equipment Evaluations
UL 900	(2004) Standard for Air Filter Units
UL Bld Mat Dir	(2009) Building Materials Directory
UL Electrical Constructn	(2007) Electrical Construction Equipment Directory
UL Fire Resistance	(2007) Fire Resistance Directory

1.2 COORDINATION OF TRADES

Furnish ductwork, piping offsets, fittings, and accessories as required to provide a complete installation and to eliminate interference with other construction.

1.3 DELIVERY AND STORAGE

Store equipment at the jobsite so that it is protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, cap or plug all pipes until installed.

1.4 FIELD MEASUREMENTS

After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting

Officer of any discrepancy before performing the work.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G, DO

Drawings showing equipment layout, including assembly and installation details and electrical connection diagrams; ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications. Include any information required to demonstrate that the system has been coordinated and will properly function as a unit on the drawings and shall show equipment relationship to other parts of the work, including clearances required for operation and maintenance.

SD-03 Product Data

Components and Equipment

Manufacturer's catalog data included with the detail drawings for the following items. Highlight the data to show model, size, options, etc., that are intended for consideration. provide adequate data to demonstrate compliance with contract requirements for the following:

Metallic Flexible Duct
Insulated Nonmetallic Flexible Duct Runouts
Duct Connectors
Duct Access Doors
Fire Dampers
Manual Balancing Dampers
Automatic Smoke Dampers
Acoustical Duct Liner
Diffusers
Registers and Grilles
Louvers
Air Vents, Penthouses, and Goosenecks
Centrifugal Fans
In-Line Centrifugal Fans
Propeller Type Power Wall Ventilators
Ceiling Exhaust Fans
Air Handling Units; G, DO
Constant Volume, Single Duct Terminal Units; G, DO
Variable Volume, Single Duct Terminal Units; G, DO
Variable Volume, Single Duct, Fan-Powered Terminal Units; G, DO
Reheat Units; G, DO
Energy Recovery Devices; G, DO
Coils

Test Procedures

Proposed test procedures and test schedules for the ductwork leak test, and performance tests of systems, at least 2 weeks prior to the start of related testing.

Diagrams; G, DO

Proposed diagrams, at least 2 weeks prior to start of related testing. System diagrams that show the layout of equipment, piping, and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed.

Operation and Maintenance Training

Proposed On-site Training schedule, submitted concurrently with the Operation and Maintenance Manuals.

SD-06 Test Reports

Performance Tests; G, DO

Test reports for the ductwork leak test, and performance tests in booklet form, upon completion of testing. Document phases of tests performed including initial test summary, repairs/adjustments made, and final test results in the reports.

Damper Acceptance Test; G

Proposed schedule, at least 2 weeks prior to the start of test.

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instructions
Operation and Maintenance Training

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

Six complete copies of the manual in bound 8 1/2 x 11 inch booklets. List step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Provide spare parts data for each different item of equipment. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replace on a routine basis.

List routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

A certified list of qualified permanent service organizations, which includes their addresses and qualifications, for support of the equipment. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide Components and equipment that are "standard products" of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. "Standard products" is defined as being in satisfactory commercial or industrial use for 2 years before bid opening. The 2-year manufacturer's experience shall include applications of components and equipment under similar circumstances and of similar size. The 2 years must be satisfactorily completed by a product that is sold on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization. Where applicable, provide equipment that is an ENERGY STAR Qualified product or a Federal Energy Management Program (FEMP) designated product.

2.2 ASBESTOS PROHIBITION

Asbestos and asbestos-containing products shall not be used.

2.3 NAMEPLATES

All equipment shall have a nameplate, installed by the manufacturer, that identifies the manufacturer's name, address, type or style, and model or serial number.

2.4 EQUIPMENT GUARDS AND ACCESS

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded according to OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. The requirements for operating platforms, ladders, and guardrails are specified in Section 05 50 00 METAL: MISCELLANEOUS AND FABRICATIONS.

2.5 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00

INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers including the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Select premium efficiency polyphase motors in accordance with NEMA MG 10.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

e. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use solid-state variable-speed controllers for motors rated 10 hp or less and adjustable frequency drives for larger motors. Provide variable frequency drives for motors as specified in Section 26 29 23 VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS.

2.6 INDOOR AIR QUALITY

All equipment and components furnished as part of this Section shall comply with the requirements of ASHRAE 62.1 unless more stringent requirements are specified herein.

2.7 DUCT SYSTEMS

2.7.1 Metal Ductwork

All aspects of metal ductwork construction, including all fittings and components, shall comply with SMACNA HVAC Duct Const Stds unless otherwise specified. Elbows shall be radius type with a centerline radius of 1.5 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes may be used. Ductwork shall meet the requirements of Seal Class A and C. All ductwork in VAV systems upstream of the VAV boxes shall meet the requirements of Seal Class A. Sealants shall conform to fire hazard classification specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS and shall be suitable for the range of air distribution and ambient

temperatures that it will be exposed to. Do not use pressure sensitive tape as a sealant. Spiral lock seam duct, and flat oval shall be made with duct sealant and locked with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA HVAC Duct Const Stds. Apply the sealant to the exposed male part of the fitting collar so that the sealer will be on the inside of the joint and fully protected by the metal of the duct fitting. Apply one brush coat of the sealant over the outside of the joint to at least 2 inch band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar will not be acceptable. Fabricate outdoor air intake ducts and plenums with watertight soldered or brazed joints and seams.

2.7.1.1 Metallic Flexible Duct

a. Duct shall conform to UL 181 and NFPA 90A with factory-applied insulation, vapor barrier, and end connections. Fire hazard rating of duct assembly shall not exceed 25 for flame spread and 50 for smoke developed. Proved ducts designed for working pressures of two inches water gauge positive and 1.5 inches water gauge negative. Flexible round duct length shall not exceed five feet. Secure connections by applying adhesive for two inches over rigid duct, apply flexible duct two inches over rigid duct, apply metal clamp, and provide minimum of three No. 8 sheet metal screws through clamp and rigid duct.

b. Inner duct core: Flexible core shall be interlocking spiral or helically corrugated and constructed of zinc-coated steel, aluminum, or stainless steel; or shall be constructed of inner liner of continuous galvanized spring steel wire helix fused to continuous, fire-retardant, flexible vapor barrier film, inner duct core.

c. Insulation: Inner duct core shall be insulated with mineral fiber blanket type flexible insulation, minimum of one inch thick. Insulation shall be covered on exterior with manufacturer's standard fire retardant vapor barrier jacket for flexible round duct.

2.7.1.2 Insulated Nonmetallic Flexible Duct Runouts

Use flexible duct runouts only where indicated. Runout length shall be as shown on the drawings, but shall in no case exceed 5 feet. Runouts shall be preinsulated, factory fabricated, and shall comply with NFPA 90A and UL 181. Provide either field or factory applied vapor barrier. Provide not less than 20 ounce glass fabric duct connectors coated on both sides with neoprene. Where coil induction or high velocity units are supplied with vertical air inlets, use a streamlined, vaned and mitered elbow transition piece for connection to the flexible duct or hose. The last elbow to these units, other than the vertical air inlet type, shall be a die-stamped elbow and not a flexible connector. Insulated flexible connectors may be used as runouts. The insulated material and vapor barrier shall conform to the requirements of Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation material surface shall not be exposed to the air stream.

2.7.1.3 General Service Duct Connectors

Provide a flexible duct connector approximately 6 inches in width where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, secure the flexible material by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, install the flexible material locked to metal collars

using normal duct construction methods. The composite connector system shall comply with NFPA 701 and be classified as "flame-retarded fabrics" in UL Bld Mat Dir.

2.7.1.4 High Temperature Service Duct Connections

Material shall be approximately 3/32 inch thick, 35 to 40-ounce per square yard weight, plain weave fibrous glass cloth with, nickel/chrome wire reinforcement for service in excess of 1200 degrees F.

2.7.1.5 Aluminum Ducts

ASTM B 209, alloy 3003-H14 for aluminum sheet and alloy 6061-T6 or equivalent strength for aluminum connectors and bar stock.

2.7.1.6 Copper Sheets

ASTM B 152/B 152M, light cold rolled temper.

2.7.1.7 Corrosion Resisting (Stainless) Steel Sheets

ASTM A 167

2.7.2 Ductwork Accessories

2.7.2.1 Duct Access Doors

Provide hinged access doors conforming to SMACNA HVAC Duct Const Stds in ductwork and plenums where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system. Provide access doors upstream and downstream of air flow measuring primaries and heating and cooling coils. Doors shall be minimum 15 x 18 inches, unless otherwise shown. Where duct size will not accommodate this size door, the doors shall be made as large as practicable. Equip doors 24 x 24 inches or larger with fasteners operable from inside and outside the duct. Use insulated type doors in insulated ducts.

2.7.2.2 Fire Dampers

Use 1.5 hour rated fire dampers unless otherwise indicated. Fire dampers shall conform to the requirements of NFPA 90A and UL 555. The Contractor shall perform the fire damper test as outlined in NFPA 90A. Provide a pressure relief damper upstream of the fire damper. If the ductwork connected to the fire damper is to be insulated then this pressure relief damper shall be factory insulated. Fire dampers shall be automatic operating type and shall have a dynamic rating suitable for the maximum air velocity and pressure differential to which it will be subjected. Fire dampers shall be approved for the specific application, and shall be installed according to their listing. Fire dampers shall be equipped with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, will not impair the operation of the damper. Equip sleeves or frames with perimeter mounting angles attached on both sides of the wall or floor opening. Construct ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies in conformance with UL Fire Resistance. Fire dampers shall be curtain type with damper blades out of the air stream. Dampers shall not reduce the duct or the air transfer opening cross-sectional area. Install dampers so that the

centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness. Unless otherwise indicated, comply with the installation details given in SMACNA Install Fire Damp HVAC and in manufacturer's instructions for fire dampers. Perform acceptance testing of fire dampers per paragraph Fire Damper Acceptance Test and NFPA 90A.

2.7.2.3 Manual Balancing Dampers

Furnish manual balancing dampers with accessible operating mechanisms. Use chromium plated operators with all exposed edges rounded in finished portions of the building. Manual volume control dampers shall be operated by locking-type quadrant operators. Dampers shall be 2 gauges heavier than the duct in which installed. Unless otherwise indicated, multileaf dampers shall be opposed blade type with maximum blade width of 12 inches. Provide access doors or panels for all concealed damper operators and locking setscrews. Unless otherwise indicated, the locking-type quadrant operators for dampers, when installed on ducts to be thermally insulated, shall be provided with stand-off mounting brackets, bases, or adapters to provide clearance between the duct surface and the operator not less than the thickness of the insulation. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer.

2.7.2.4 Automatic Smoke Dampers

UL listed multiple blade type, supplied by smoke damper manufacturer, with pneumatic damper operator as part of assembly. Qualified under UL 555S with a leakage rating no higher than class II or III at an elevated temperature Category B (250 degrees F for 30 minutes). Pressure drop in the damper open position shall not exceed 0.1 inch water gauge with average duct velocities of 2500 fpm.

2.7.2.5 Air Deflectors and Branch Connections

Provide air deflectors at all duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections may be used in lieu of deflectors for branch connections. Furnish all air deflectors, except those installed in 90 degree elbows, with an approved means of adjustment. Adjustment shall be made from easily accessible means inside the duct or from an adjustment with sturdy lock on the face of the duct. When installed on ducts to be thermally insulated, external adjustments shall be provided with stand-off mounting brackets, integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Air deflectors shall be factory-fabricated units consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Air deflectors shall be factory or field assembled. Adjustment shall be easily made from the face of the diffuser or by position adjustment and lock external to the duct. Stand-off brackets shall be provided on insulated ducts and are described herein. Fixed air deflectors, also called turning vanes, shall be provided in 90 degree elbows.

2.7.2.6 Dampers, Face and By-Pass Dampers

Where outdoor air supply and exhaust air dampers are required they shall

have a maximum leakage rate when tested in accordance with AMCA 500-D as required by ASHRAE 90.1 - IP, including: Maximum Damper Leakage for: 1) Climate Zones 1,2,6,7,8 the maximum damper leakage at 1.0 inch w.g. for motorized dampers is 4 cfm per SQFT of damper area and non-motorized dampers are not allowed. 2) All other Climate Zones the maximum damper leakage at 1.0 inch w.g. is 10 cfm per SQFT and for non-motorized dampers is 20 cfm per SQFT of damper area.
Dampers smaller than 24 inches in either direction may have leakage of 40 cfm per SQFT.

2.7.3 Plenums and Casings for Field-Fabricated Units

2.7.3.1 Plenum and Casings

Fabricate and erect plenums and casings as shown in SMACNA HVAC Duct Const Stds, as applicable. Construct system casing of not less than 16 gauge galvanized sheet steel. Furnish cooling coil drain pans with 1 inch threaded outlet to collect condensation from the cooling coils. Fabricate drain pans from not lighter than 16 gauge steel, galvanized after fabrication or of 18 gauge corrosion-resisting sheet steel conforming to ASTM A 167, Type 304, welded and stiffened. Thermally insulate drain pans exposed to the atmosphere to prevent condensation. Insulation shall be coated with a flame resistant waterproofing material. Provide separate drain pans for each vertical coil section, and a separate drain line for each pan. Size pans to ensure capture of entrained moisture on the downstream-air side of the coil. Seal openings in the casing, such as for piping connections, to prevent air leakage. Size the water seal for the drain to maintain a pressure of at least 2 inch water gauge greater than the maximum negative pressure in the coil space.

2.7.3.2 Casing

Terminate casings at the curb line and bolt each to the curb using galvanized angle, as indicated in SMACNA HVAC Duct Const Stds.

2.7.3.3 Access Doors

Provide access doors in each section of the casing. Weld doorframes in place, gasket each door with neoprene, hinge with minimum of two brass hinges, and fasten with a minimum of two brass tension fasteners operable from inside and outside of the casing. Where possible, doors shall be 36 x 18 inches located 18 inches above the floor. Where the space available will not accommodate doors of this size, use doors as large as the space will accommodate. Doors shall swing so that fan suction or pressure holds door in closed position, and shall be airtight.

2.7.3.4 Factory-Fabricated Insulated Sheet Metal Panels

Factory-fabricated components may be used for field-assembled units, provided all requirements specified for field-fabricated plenums and casings are met. Panels shall be of modular design, pretested for structural strength, thermal control, condensation control, and acoustical control. Panel joints shall be sealed and insulated access doors shall be provided and gasketed to prevent air leakage. Panel construction shall be not less than 20 gauge galvanized sheet steel and shall be assembled with fasteners treated against corrosion. Standard length panels shall deflect not more than 1/2 inch under operation. Details of construction, including joint sealing, not specifically covered shall be as indicated in SMACNA HVAC Duct Const Stds. Construct the plenums and casings to

withstand the specified internal pressure of the air systems.

2.7.3.5 Duct Liner

Unless otherwise specified, duct liner shall conform to ASTM C 1071, Type I or II.

2.7.4 Diffusers, Registers, and Grilles

Units shall be factory-fabricated of steel or aluminum and shall distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 50 fpm in occupied zone, or dead spots anywhere in the conditioned area. Outlets for diffusion, spread, throw, and noise level shall be as required for specified performance. Performance shall be certified according to ASHRAE 70. Inlets and outlets shall be sound rated and certified according to ASHRAE 70. Sound power level shall be as indicated. Diffusers and registers shall be provided with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device will be acceptable. Volume dampers shall be opposed blade type for all diffusers and registers, except linear slot diffusers. Provide linear slot diffusers with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 7 feet above the floor, they shall be protected by a grille or screen according to NFPA 90A.

2.7.4.1 Diffusers

Diffuser types shall be as indicated. Furnish ceiling mounted units with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Provide diffusers with air deflectors of the type indicated. Air handling troffers or combination light and ceiling diffusers shall conform to the requirements of UL Electrical Constructn for the interchangeable use as cooled or heated air supply diffusers or return air units. Install ceiling mounted units with rims tight against ceiling. Provide sponge rubber gaskets between ceiling and surface mounted diffusers for air leakage control. Suitable trim shall be provided for flush mounted diffusers. Duct collar connecting the duct to diffuser shall be airtight and shall not interfere with volume controller. Return or exhaust units shall be similar to supply diffusers.

2.7.4.2 Registers and Grilles

Units shall be four-way directional-control type, except that return and exhaust registers may be fixed horizontal or vertical louver type similar in appearance to the supply register face. Furnish registers with sponge-rubber gasket between flanges and wall or ceiling. Install wall supply registers at least 6 inches below the ceiling unless otherwise indicated. Locate return and exhaust registers 6 inches above the floor unless otherwise indicated. Four-way directional control may be achieved by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Grilles shall be as specified for registers, without volume control damper.

2.7.4.3 Registers

Double-deflection supply registers. Provide manufacturer-furnished volume dampers. Volume dampers shall be of the group-operated, opposed-blade type and key adjustable by inserting key through face of register. Operating mechanism shall not project through any part of the register face.

Automatic volume control devices will be acceptable.

2.7.5 Louvers

Louvers for installation in exterior walls that are associated with the air supply and distribution system shall be as specified in Section 08 91 00 METAL WALL AND DOOR LOUVERS.

2.7.6 Air Vents, Penthouses, and Goosenecks

Fabricate Air vents, penthouses, and goosenecks from galvanized steel sheets with galvanized structural shapes. Sheet metal thickness, reinforcement, and fabrication shall conform to SMACNA HVAC Duct Const Stds. Accurately fit and secure louver blades to frames. Fold or bead edges of louver blades for rigidity and baffle these edges to exclude driving rain. Provide air vents, penthouses, and goosenecks with bird screen.

2.7.7 Bird Screens and Frames

Bird screens shall conform to ASTM E 2016, No. 2 mesh, aluminum or stainless steel. Aluminum screens shall be rated "medium-light". Stainless steel screens shall be rated "light". Frames shall be removable type, and fabricated from either stainless steel or extruded aluminum.

2.8 AIR SYSTEMS EQUIPMENT

2.8.1 Fans

Fans shall be tested and rated according to AMCA 210. Calculate system effect on air moving devices in accordance with AMCA 201 where installed ductwork differs from that indicated on drawings. Install air moving devices to minimize fan system effect. Where system effect is unavoidable, determine the most effective way to accommodate the inefficiencies caused by system effect on the installed air moving device. The sound power level of the fans shall not exceed 85 dBA when tested per AMCA 300 and rated per AMCA 301. All fans shall have an AMCA seal. Connect fans to the motors either directly or indirectly with V-belt drive. Use V-belt drives designed for not less than140 percent of the connected driving capacity. Motor sheaves shall be variable pitch for 15 hp and below and fixed pitch as defined by ARI Guideline D. Select variable pitch sheaves to drive the fan at a speed which will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, provide a replaceable sheave when needed to achieve system air balance. Provide motors for V-belt drives with adjustable rails or bases. Provide removable metal guards for all exposed V-belt drives, and provide speed-test openings at the center of all rotating shafts. Provide fans with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Use vibration-isolation units that are standard products with published loading ratings. Select each fan to produce the capacity required at the fan static pressure indicated. Sound power level shall be as indicated. Obtain the sound power level values according to AMCA 300. Standard AMCA arrangement, rotation, and discharge shall be as indicated. Power ventilators shall conform to UL 705 and shall have a UL label.

2.8.1.1 Centrifugal Fans

Centrifugal fans shall be fully enclosed, single-width single-inlet, AMCA Pressure Class I, II, or III as required or indicated for the design system pressure. Impeller wheels shall be rigidly constructed, accurately balanced both statically and dynamically. Fan blades may be forward curved or backward-inclined airfoil design in wheel sizes up to 30 inches. Fan blades for wheels over 30 inches in diameter shall be backward-inclined airfoil design. Booster fans for exhaust dryer systems shall be the open-wheel radial type. These fans shall be suitable for conveying lint and the temperatures encountered. Equip the fan shaft with a heat slinger to dissipate heat buildup along the shaft. Install an access (service) door to facilitate maintenance to these fans. Fan wheels over 36 inches in diameter shall have overhung pulleys and a bearing on each side of the wheel. Fan wheels 36 inches or less in diameter may have one or more extra long bearings between the fan wheel and the drive. Bearings shall be sleeve type, self-aligning and self-oiling with oil reservoirs, or precision self-aligning roller or ball-type with accessible grease fittings or permanently lubricated type. Grease fittings shall be connected to tubing and serviceable from a single accessible point. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Fan shafts shall be steel, accurately finished, and shall be provided with key seats and keys for impeller hubs and fan pulleys. Each fan outlet shall be of ample proportions and shall be designed for the attachment of angles and bolts for attaching flexible connections. Automatically operated outlet dampers shall be provided. Motors, unless otherwise indicated, shall not exceed 1800 rpm and shall have open, dripproof or totally enclosed enclosures. Where variable frequency drives are not provided, motor starters shall be reduced-voltage-start type with general-purpose enclosure. Provide remote manual switch with pilot indicating light where indicated.

2.8.1.2 In-Line Centrifugal Fans

In-line fans shall have centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Mount fans in a welded tubular casing. Air shall enter and leave the fan axially. Streamline inlets with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Enclose and isolate fan bearings and drive shafts from the air stream. Fan bearings shall be sealed against dust and dirt and shall be permanently lubricated, and shall be precision, self aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Motors shall have open, dripproof enclosure. Provide remote manual switch with pilot indicating light where indicated.

2.8.2 Coils

Coils shall be fin-and-tube type constructed of seamless copper tubes and aluminum fins mechanically bonded or soldered to the tubes. Copper tube wall thickness shall be a minimum of 0.020 inches. Aluminum fins shall be 0.0055 inch minimum thickness. Casing and tube support sheets shall be not lighter than 16 gauge galvanized steel, formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. Each coil shall be tested at the factory under water at not less than 400 psi air pressure and shall be suitable for 200 psi working pressure and 300 degrees F operating temperature unless otherwise stated. Mount coils for counterflow service. Coils shall be rated and certified and meet the requirements of ARI 410.

2.8.2.1 Water Coils

Install water coils with a pitch of not less than 1/8 inch/foot of the tube length toward the drain end. Use headers constructed of cast iron, welded steel or copper. Furnish each coil with a plugged vent and drain connection extending through the unit casing. Water coils shall be removable and have drain pans.

2.8.2.2 Eliminators

Equip each cooling coil and exhaust side of the heat-pipe (IDEC) energy recovery coil having an air velocity of over 400 fpm through the net face area with moisture eliminators, unless the coil manufacturer guarantees, over the signature of a responsible company official, that no moisture will be carried beyond the drip pans under actual conditions of operation. Construct of minimum 24 gage zinc-coated steel, copper, copper nickel or stainless steel, removable through the nearest access door in the casing or ductwork. Eliminators shall have not less than two bends at 45 degrees and shall be spaced not more than 2-1/2 inches center-to-center on face. Each bend shall have an integrally formed hook as indicated in the SMACNA FGDCS.

2.8.3 Air Filters

Air filters shall be listed according to requirements of UL 900, except high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test method shall be as listed under the Label Service and shall meet the requirements of UL 586.

2.8.3.1 Extended Surface Pleated Panel Filters

Filters shall be 2 inch depth, sectional, disposable type of the size indicated and shall have a MERV of 8 when tested according to ASHRAE 52.2. Initial resistance at 500 fpm shall not exceed 0.36 inches water gauge. Filters shall be UL Class 2. Media shall be nonwoven cotton and synthetic fiber mat. A wire support grid bonded to the media shall be attached to a moisture resistant fiberboard frame. All four edges of the filter media shall be bonded to the inside of the frame to prevent air bypass and increase rigidity.

2.8.3.2 Cartridge Type Filters

Filters shall be 12 inch depth, sectional, replaceable dry media type of the size indicated and shall have a MERV of 13 when tested according to ASHRAE 52.2. Initial resistance at 500 fpm shall not exceed 0.56 inches, water gauge. Filters shall be UL class 1. Media shall be pleated microglass paper media with corrugated aluminum separators, sealed inside the filter cell to form a totally rigid filter assembly. Fluctuations in filter face velocity or turbulent airflow will have no effect on filter integrity or performance. Each filter shall be installed with an extended surface pleated media panel filter as a prefilter in a factory preassembled side access housing, or a factory-made sectional frame bank, as indicated.

2.8.3.3 Electrostatic Filters

Electrostatic filters shall be the combination dry agglomerator/extended surface nonsupported pocket filter or the combination dry agglomerator/automatic renewable media (roll) type, as indicated (except as modified). Each dry agglomerator electrostatic air filter shall be

supplied with the correct quantity of fully housed power packs and equipped with silicon rectifiers, manual reset circuit breakers, low voltage safety cutout, relays for field wiring to remote indication of primary and secondary voltages, and lamps mounted in the cover to indicate these functions locally. Power pack enclosure shall be equipped with external mounting brackets, and low and high voltage terminals shall be fully exposed with access cover removed for ease of installation. Furnish interlock safety switches for each access door and access panel that permits access to either side of the filter, so that the filter will be de-energized in the event that a door or panel is opened. Ozone generation within the filter shall not exceed five parts per one hundred million parts of air. High voltage insulators shall be located outside the moving air stream or on the clean air side of the unit and shall be serviceable. Ionizer wire supports shall be fully exposed and ionizer wires shall be furnished precut to size and with formed loops at each end to facilitate ionizer wire replacement. Agglomerator cell plates shall allow proper air stream entrainment of agglomerates and prevent excessive residual dust build-up. Cells shall be open at the top and bottom to prevent accumulation of agglomerates which settle by gravity. Where the dry agglomerator electrostatic filter is indicated to be the automatic renewable media type, the storage section shall utilize a horizontal or vertical traveling curtain of adhesive-coated bonded fibrous glass for dry agglomerator storage section service and supplied in 65 foot lengths in convenient roll form. Storage section construction and roll media characteristics shall otherwise be as specified for automatic renewable media filters. Initial air flow resistance of the dry agglomerator/renewable media combination, after installation of clean media, shall not exceed 0.25 inch water gauge at 500 fpm face velocity. The MERV of the combination shall be not less than 15 when tested according to ASHRAE 52.2 at an average operating resistance of 0.50 inch water gauge. Where the dry agglomerator electrostatic filter is indicated to be of the extended surface nonsupported pocket filter type, the storage section shall be as specified for extended surface non-supported pocket filters, with sectional holding frames or side access housings as indicated. Initial air flow resistance of the dry agglomerator/extended surface nonsupported pocket filter section combination, after installation of clean filters, shall not exceed 0.65 inch water gauge at 500 fpm face velocity. The MERV of the combination shall be not less than 16 when tested according to ASHRAE 52.2. Front access filters shall be furnished with full height air distribution baffles and upper and lower mounting tracks to permit the baffles to be moved for agglomerator cell inspection and service. When used in conjunction with factory fabricated air handling units, side access housings shall be supplied which have dimensional compatibility.

2.8.3.4 Holding Frames

Fabricate frames from not lighter than 16 gauge sheet steel with rust-inhibitor coating. Equip each holding frame with suitable filter holding devices. Holding frame seats shall be gasketed. All joints shall be airtight.

2.8.3.5 UV-C Emitters

Ultraviolet light C band (UV-C) emitters shall be incorporated to shine on the electrostatic filters to control airborne and surface microbial growth and transfer. Applied units must be specifically manufactured for this purpose. Safety features shall be provided to limit hazard to operating staff. Units shall not produce ozone.

1. An individual array that will provide a barrier wall of germicidal UV energy that will treat the surface area of the filter.
2. The high intensity UV-C lamps will be of the low-pressure mercury laden argon-neon type that incorporates a getter assembly to reduce and control the mercury levels.
3. The purifier will carry a 2 year warranty on parts, 12,000 hours on the UV lamps.
4. The purifier must be CSA or UL Certified.
5. UV-C emitters are not required for evaporative cooling system sumps.
6. A door interlock shall be provided to de-energize the UV-C system when the door is open.
7. Provide a portable UV intensity test kit for maintenance staff to measure UV-C intensity. Test kit shall include a data logging function to record UV-C intensity over a 30 minute duration.

2.8.3.6 Filter Gauges

Filter gauges shall be dial type, diaphragm actuated draft and shall be provided for all filter stations, including those filters which are furnished as integral parts of factory fabricated air handling units. Gauges shall be at least 3-7/8 inches in diameter, shall have white dials with black figures, and shall be graduated in 0.01 inch of water, and shall have a minimum range of 1 inch of water beyond the specified final resistance for the filter bank on which each gauge is applied. Each gauge shall incorporate a screw operated zero adjustment and shall be furnished complete with two static pressure tips with integral compression fittings, two molded plastic vent valves, two 5 foot minimum lengths of 1/4 inch diameter vinyl tubing, and all hardware and accessories for gauge mounting.

2.9 AIR HANDLING UNITS

2.9.1 Factory-Fabricated Air Handling Units

Units shall be single-zone blow-through dedicated outside air unit, blow-through triple deck type as indicated. Units shall include fans, coils, airtight insulated casing, prefilters, secondary filter sections, and adjustable V-belt drives, belt guards for externally mounted motors, access sections where indicated, combination sectional filter-mixing box, vibration-isolators, and appurtenances required for specified operation. Vibration isolators shall be as indicated. Each air handling unit shall have physical dimensions suitable to fit space allotted to the unit and shall have the capacity indicated. Air handling unit shall be rated in accordance with ARI 430 and ARI certified for cooling.

2.9.1.1 Casings

Casing sections shall be 2 inch double wall type or as indicated, constructed of a minimum 18 gauge galvanized steel, or 18 gauge corrosion-resisting sheet steel conforming to ASTM A 167, Type 304, downstream of the exhaust side of the heat pipe shall be 304L stainless steel. Inner casing of double-wall units shall be minimum 20 gauge solid galvanized steel or corrosion-resisting sheet steel conforming to ASTM A 167, Type 304. Design and construct casing with an integral insulated structural galvanized steel frame such that exterior panels are non-load bearing. Exterior panels shall be individually removable with standard tools. Removal shall not affect the structural integrity of the unit. Furnish casings with inspection doors, access sections, and access doors, all capable of opening a minimum of 90 degrees, as indicated. Inspection and access doors shall be insulated, fully gasketed, double-wall type, of a

minimum 18 gauge outer and 20 gauge inner panels made of either galvanized steel or corrosion-resisting sheet steel conforming to ASTM A 167, Type 304. Doors shall be rigid and provided with heavy duty hinges and latches. Inspection doors shall be a minimum 12 inches wide by 12 inches high. Access doors shall be minimum 24 inches wide and shall be the full height of the unit casing or a minimum of 6 foot, whichever is less. A minimum 8 by 8 inches sealed glass window suitable for the intended application shall be installed in all access doors. Access Sections shall be according to paragraph AIR HANDLING UNITS. Drain pan shall be double-wall insulated type (thickness equal to exterior casing) constructed of 16 gauge corrosion resisting sheet steel conforming to ASTM A 167, Type 304L, conforming to ASHRAE 62.1. Construct drain pans water tight, treated to prevent corrosion, and designed for positive condensate drainage. When 2 or more cooling coils are used, with one stacked above the other, condensate from the upper coils shall not flow across the face of lower coils. Provide intermediate drain pans or condensate collection channels and downspouts, as required to carry condensate to the unit drain pan out of the air stream and without moisture carryover. Construct drain pan so that the pan may be visually inspected easily including underneath the coil without removal of the coil and so that the pan may be physically cleaned completely and easily underneath the coil without removal of the coil. Coils shall be individually removable from the casing. Casing insulation shall conform to NFPA 90A. Single-wall casing sections handling conditioned air shall be insulated with not less than 1 inch thick, 1-1/2 pound density coated fibrous glass material having a thermal conductivity not greater than 0.23 Btu/hr-sf-F. Double-wall casing sections handling conditioned air shall be insulated with not less than 2 inches of the same insulation specified for single-wall casings. Foil-faced insulation shall not be an acceptable substitute for use with double wall casing. Double wall insulation must be completely sealed by inner and outer panels. Factory applied fibrous glass insulation shall conform to ASTM C 1071, except that the minimum thickness and density requirements do not apply, and shall meet the requirements of NFPA 90A. Air handling unit casing insulation shall be uniform over the entire casing. Foil-faced insulation shall not be an acceptable substitute for use on double-wall access doors and inspections doors and casing sections. Duct liner material, coating, and adhesive shall conform to fire-hazard requirements specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Protect exposed insulation edges and joints where insulation panels are butted with a metal nosing strip or shall be coated to conform to meet erosion resistance requirements of ASTM C 1071. Provide a latched and hinged inspection door, in the fan and coil sections. Provide additional inspection doors, access doors and access sections where indicated.

2.9.1.2 Heating and Cooling Coils

Coils shall be provided as specified in paragraph AIR SYSTEMS EQUIPMENT.

2.9.1.3 Air Filters

Air filters shall be as specified in paragraph AIR SYSTEMS EQUIPMENT for types and thickness indicated.

2.9.1.4 Fans

Provide fans that meet the requirements of ASHRAE 90.1 - IP as specified in paragraph AIR SYSTEMS EQUIPMENT. Fans shall be double-inlet, centrifugal type with each fan in a separate scroll. Fans and shafts shall be dynamically balanced prior to installation into air handling unit, then the

entire fan assembly shall be statically and dynamically balanced at the factory after it has been installed in the air handling unit. Mount fans on steel shafts, accurately ground and finished. Fan bearings shall be sealed against dust and dirt and shall be precision self-aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Bearings shall be permanently lubricated or lubricated type with lubrication fittings readily accessible at the drive side of the unit. Bearings shall be supported by structural shapes, or die formed sheet structural members, or support plates securely attached to the unit casing. Bearings may not be fastened directly to the unit sheet metal casing. Furnish fans and scrolls with coating indicated. Fans shall be driven by a unit-mounted or a floor-mounted motor connected to fans by V-belt drive complete with belt guard for externally mounted motors. Belt guards shall be the three-sided enclosed type with solid or expanded metal face. Belt drives shall be designed for not less than a 1.3 service factor based on motor nameplate rating. Motor sheaves shall be variable pitch for 25 hp and below and fixed pitch above 25 hp as defined by ARI Guideline D. Where fixed sheaves are required, variable pitch sheaves may be used during air balance, but shall be replaced with an appropriate fixed sheave after air balance is completed. Select variable pitch sheaves to drive the fan at a speed that will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. Furnish motors for V-belt drives with adjustable bases. Fan motors shall have totally enclosed enclosures. Motor starters shall be reduced-voltage-start type with general-purpose enclosure. Unit fan or fans shall be selected to produce the required capacity at the fan static pressure. Sound power level shall be as indicated. The sound power level values shall be obtained according to AMCA 300, ASHRAE 68, or ARI 260.

2.9.1.5 Access Sections and Filter/Mixing Boxes

Provide access sections where indicated and furnish with access doors as shown. Construct access sections and filter/mixing boxes in a manner identical to the remainder of the unit casing and equip with access doors. Design mixing boxes to minimize air stratification and to promote thorough mixing of the air streams.

2.9.1.6 Dampers

Dampers shall be as specified in paragraphs CONTROLS and DUCT ACCESSORIES.

2.10 TERMINAL UNITS

2.10.1 Coils

Fabricate coils from not less than 3/8 inch outside diameter seamless copper tubing, with copper or aluminum fins mechanically bonded or soldered to the tubes. Provide coils with not less than 1/2 inch outside diameter flare or sweat connectors, accessory piping package with thermal connections suitable for connection to the type of control valve supplied, and manual air vent. Test coils hydrostatically at 300 psi or under water at 250 psi air pressure. Coils shall be suitable for 200 psi working pressure. Make provisions for coil removal.

2.10.2 Variable Air Volume (VAV) Terminal Units

VAV and dual duct terminal units shall be the type, size, and capacity shown and shall be mounted in the ceiling or wall cavity and shall be suitable for single or dual duct system applications. Actuators and

controls shall be as specified in paragraph CONTROLS. Unit enclosures shall be constructed of galvanized steel not lighter than 22 gauge or aluminum sheet not lighter than 18 gauge. Single or multiple discharge outlets shall be provided as required. Units with flow limiters are not acceptable. Unit air volume shall be factory preset and readily field adjustable without special tools. Provide reheat coils as indicated. Attach a flow chart to each unit. Base acoustic performance of the terminal units upon units tested according to ARI 880 with the calculations prepared in accordance with ARI 885. Sound power level shall be as indicated. Discharge sound power shall be shown for minimum and 1-1/2 inches water gauge inlet static pressure. Acoustical lining shall be according to NFPA 90A.

2.10.2.1 Constant Volume, Single Duct Terminal Units

Constant volume, single duct, terminal units shall contain within the casing, a constant volume regulator. Volume regulators shall control air delivery to within plus or minus 5 percent of specified air flow subjected to inlet pressure from 3/4 to 6 inch water gauge.

2.10.2.2 Variable Volume, Single Duct Terminal Units

Provide variable volume, single duct, terminal units with a calibrated air volume sensing device, air valve or damper, actuator, and accessory relays. Units shall control air volume to within plus or minus 5 percent of each air set point volume as determined by the thermostat with variations in inlet pressures from 3/4 to 6 inch water gauge. Internal resistance of units shall not exceed 0.4 inch water gauge at maximum flow range. Provide external differential pressure taps separate from the control pressure taps for air flow measurement with a 0 to 1 inch water gauge range.

2.10.2.3 Variable Volume, Single Duct, Fan-Powered Terminal Units

Provide variable volume, single duct, fan-powered terminal units with a calibrated air volume sensing device, air valve or damper, actuator, fan and motor, and accessory relays. Units shall control primary air volume to within plus or minus 5 percent of each air set point as determined by the thermostat with variations in inlet pressure from 3/4 to 6 inch water gauge. Unit fan shall be centrifugal, direct-driven, double-inlet type with forward curved blades. Fan motor shall be either single speed with speed controller or three-speed, permanently lubricated, permanent split-capacitor type. Isolate fan/motor assembly from the casing to minimize vibration transmission. Fan control shall be factory furnished and wired into the unit control system. Provide a factory-mounted pressure switch to operate the unit fan whenever pressure exists at the unit primary air inlet or when the control system fan operates.

2.10.2.4 Series Fan Powered Variable Air Volume (VAV) Terminals

Provide units factory assembled, designed, tested, and rated in accordance with ARI 880. Units shall be ARI certified and listed in the ARI DCAACP. Units shall provide a supply air discharge mix by modulation of conditioned primary air and recirculating of return air. Units shall include casing, centrifugal fan and motor, primary VAV damper or valve, electronic volume regulator, discharge air damper, primary air inlet cone with high and low pressure flow sensors, recirculating air filter frames, filter, and electrical disconnect. Provide hot water heating coils integral to the terminal, or provide insulated hot water coil section attached to the

discharge of the terminal.

a. Casing: Provide removable full bottom access panels for servicing internal components without disturbing duct connections. Insulate inside of casing with manufacturer's standard insulation. Units shall have recirculating air inlet equipped with filter frame, round primary damper or valve, and unit mounting brackets.

b. Fans and motors: Provide centrifugal, forward curved, multiblade, fan wheels with direct-drive motors. Motors shall be premium efficiency in accordance with NEMA MG 1, permanent-split capacitor type with thermal overload protection and permanently lubricated bearings. Motors shall have three speeds or be equipped with solid state speed controllers. Provide isolation between fan motor assembly and unit casing. Fan and motor shall be removable through casing access panel.

c. Flow sensor: Sensor shall be ring or cross type with minimum of two pickup points which average the velocity across the inlet. Flow measurement shall be within plus or minus 5 percent of rated airflow with 1.5 diameters of straight duct upstream of unit and inlet static variation of 0.5 to 5.0 inches water gauge. Flow measuring taps and calibration flowchart shall be supplied with each unit for field balancing airflows.

d. Primary VAV damper or valve: Galvanized steel damper blade shall close against gasket inside unit. Connect damper to operating shaft with a positive mechanical connection. Provide nylon bearing for damper shaft. Cylindrical die cast aluminum valve inlet tapered to fit round flexible ducts with integral flow diffuser and beveled self-centering disc. Damper or valve leakage at shutoff shall not exceed 2 percent of capacity at 1 inch water gauge pressure.

e. Regulator: Volume regulator shall be electronic. Electronic controls contained in NEMA ICS 6, Type 1 enclosure sealed from airflow. Controls shall be mounted on side of unit or on air valve. System powered regulators shall not be permitted. Volume regulator shall reset primary air volume as determined by thermostat, within upstream static pressure variation noted in paragraph entitled "Flow Sensor." Volume regulators shall be field adjustable and factory set and calibrated to indicated maximum and minimum primary airflows.

f. Electrical: Unit shall incorporate single point electrical connection with electrical disconnect. Electrical components shall be UL or ETL listed and installed in accordance with NFPA 70. Electrical components shall be mounted in control box. Units UL or ETL listed as an assembly do not require airflow switch interlock with electric heating coil when factory assembled.

g. Filters: Provide UL listed throwaway one inch thick fiberglass filters, standard dust-holding capacity.

2.10.2.5 Reheat Units

a. Hot Water Coils: Hot-water coils shall be fin-and-tube type constructed of seamless copper tubes and copper or aluminum fins mechanically bonded or soldered to the tubes. Headers shall be constructed of cast iron, welded steel or copper. Casing and tube support sheets shall be 16 gauge, galvanized steel, formed to provide structural strength. Tubes shall be correctly circuited

for proper water velocity without excessive pressure drop and they shall be drainable where required or indicated. At the factory, each coil shall be tested at not less than 250 psi air pressure and shall be suitable for 200 psi working pressure. Install drainable coils in the air handling units with a pitch of not less than 1/8 inch per foot of tube length toward the drain end. Coils shall conform to the provisions of ARI 410.

2.11 ENERGY RECOVERY DEVICES

2.11.1 Direct Evaporative Spray and Heat Recovery Heat Pipe

Device shall be a factory fabricated, assembled and tested, counterflow arrangement, air-to-air heat exchanger for transfer of sensible heat between exhaust and supply streams. Device shall deliver an energy transfer effectiveness not less than that indicated without cross-contamination. Heat exchanger tube core shall be 5/8 inch nominal diameter, seamless aluminum or copper tube with extended surfaces, utilizing wrought aluminum Alloy 3003 or Alloy 5052, temper to suit. Maximum fins per unit length and number of tube rows shall be as indicated. Tubes shall be fitted with internal capillary wick, filled with an ASHRAE 15, Group 1 refrigerant working fluid, selected for system design temperature range, and hermetically sealed. Heat exchanger frame shall be constructed of not less than 16 gauge galvanized steel and fitted with intermediate tube supports, and flange connections. Tube end-covers and a partition of galvanized steel to separate exhaust and supply air streams without cross-contamination and in required area ratio shall be provided. A drain pan constructed of welded Type 304L series stainless steel shall be provided. Heat recovery regulation shall be provided bysystem face and bypass dampers and related control system as indicated. The wrap around heat pipe will be self controlling. Coil shall be fitted with pleated flexible connectors.

2.11.1.1 Water Blowdown Equipment

Water shall be periodically dumped (approximately every six to twelve hours). This shall be done by either the use of a mechanical timer or by measuring the conductivity and dumping the water when the conductivity reaches 1500-2000 micro mhos.

2.11.1.2 Water Distribution Header

The water distribution header shall be a nonwettable, nondrip type. Water shall be distributed by means of PVC header and nozzles, which shall impart a fine water mist into the scavenger air side of the heat exchanger.

2.11.1.3 Water Pump

The water pump shall be a self-priming centrifugal type with capacity and head characteristics for the specified operation of the unit. The motor shaft shall be constructed of stainless steel, cadmium coated steel or hot-dip zinc galvanized steel. The impeller shall be constructed of stainless steel or polymeric material conforming to UL 746C. Pump housing shall be constructed of factory hot-dip zinc coated steel or polymeric material conforming to UL 746C. Pump housing bottom shall be removable for impeller cleaning and shall not permit galvanic action with cooler bottom. Pump shall have permanently sealed and lubricated bearings and fan cooled motor with moisture proof winding. Pump motor shall be provided with a factory installed three conductor rubber sheathed flexible cord with the

third wire being the grounding conductor. Water pump shall be provided with a filter screen constructed of plastic which shall project 1 inch above the high water level of the water tank.

2.11.1.4 Water Treatment for the Evaporative Cooling System

Provide complete and ready for operation, factory packaged water treatment unit for ozone treatment of water. The water treatment shall generate ozone by passing 15 to 30 psig instrument quality compressed air through an ultra violet lamp panel sized for the unit water flow and airflow. The reaction column shall be sized (diameter and length) to provide a minimum of a 3 second control time of the evaporative cooling sump water being exposed the bubbling ozone. The reaction column shall be constructed of clear PVC (allowing the ozoneated compressed air bubbles to be directly observed). It is recommended that the reaction column should be 5 feet long.

2.11.1.5 Air Compressor

The instrument air compressor shall be oil free design that produces instrument quality air. The compressor shall be designed to operate continuously and to supply the optimum air pressure to drive both the lamp panel and the Reaction Column. The compressor shall be designed for low maintenance under rugged duty conditions and provide sound suppression. The unit shall include a safety valve and filter/silencer. Vertical wall mounting is acceptable. 115V/1/60.

The instrument air compressor shall run when the sum pump is operating and when the sump pump is shut off, the instrument air compressor shall be shut off.

2.11.2 Wrap Around Heat Pipe

Device shall be a factory fabricated, assembled and tested, counterflow arrangement, air-to-air heat exchanger for transfer of sensible heat between exhaust and supply streams. Device shall deliver an energy transfer effectiveness not less than that indicated without cross-contamination. Heat exchanger tube core shall be 5/8 inch nominal diameter, seamless aluminum or copper tube with extended surfaces, utilizing wrought aluminum Alloy 3003 or Alloy 5052, temper to suit. Maximum fins per unit length and number of tube rows shall be as indicated. Tubes shall be fitted with internal capillary wick, filled with an ASHRAE 15, Group 1 refrigerant working fluid, selected for system design temperature range, and hermetically sealed. Heat exchanger frame shall be constructed of not less than 16 gauge galvanized steel and fitted with intermediate tube supports, and flange connections. Tube end-covers and a partition of galvanized steel to separate exhaust and supply air streams without cross-contamination and in required area ratio shall be provided. A drain pan constructed of welded Type 304L series stainless steel shall be provided. The wrap around heat pipe will be self controlling. Coil shall be fitted with pleated flexible connectors.

2.12 FACTORY PAINTING

Units which are not of galvanized construction according to ASTM A 123/A 123M or ASTM A 924/A 924M shall be factory painted with a corrosion resisting paint finish. Internal and external ferrous metal surfaces shall be cleaned, phosphatized and coated with a paint finish which has been tested according to ASTM B 117, ASTM D 1654, and ASTM D 3359.

Evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors shall be submitted. Rating of failure at the scribe mark shall be not less than 6, average creepage not greater than 1/8 inch. Rating of the inscribed area shall not be less than 10, no failure. On units constructed of galvanized steel that have been welded, exterior surfaces of welds or welds that have burned through from the interior shall receive a final shop docket of zinc-rich protective paint according to ASTM D 520 Type I.

2.13 FIELD PAINTING

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F shall be cleaned to bare metal. Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

a. Temperatures less than 120 degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat.

b. Temperatures between 120 and 400 degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F shall receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of two mils.

c. Temperatures greater than 400 degrees F: Metal surfaces subject to temperatures greater than 400 degrees F shall receive two coats of 315 degrees C 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of two mils.

2.14 SUPPLEMENTAL COMPONENTS/SERVICES

2.14.1 Chilled, Condenser, or Dual Service Water Piping and Accessories

The requirements for chilled, condenser, or dual service water piping and accessories are specified in Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS

2.14.2 Water or Steam Heating System Accessories

The requirements for water or steam heating accessories such as expansion tanks and steam traps are specified in Section 23 52 00.00 10 WATER AND STEAM HEATING; OIL, GAS OR BOTH; UP TO 20 MBTUH.

2.14.3 Condensate Drain Lines

Provide and install condensate drainage for each item of equipment that generates condensate in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE or 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS except as modified herein.

2.14.4 Backflow Preventers

The requirements for backflow preventers are specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.14.5 Insulation

The requirements for shop and field applied insulation are specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.14.6 Controls

The requirements for controls are specified in Section 23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS and Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS.

PART 3 EXECUTION

3.1 INSTALLATION

Installation shall be as shown and according to the manufacturer's diagrams, recommendations and manufacturer's installation instructions.

3.1.1 Condensate Drain Lines

Water seals shall be provided in the condensate drain from all units. The depth of each seal shall be 2 inches plus the number of inches, measured in water gauge, of the total static pressure rating of the unit to which the drain is connected. Water seals shall be constructed of 2 tees and an appropriate U-bend with the open end of each tee plugged. Pipe cap or plug cleanouts shall be provided where indicated. Drains indicated to connect to the sanitary waste system shall be connected by an indirect waste fitting. Air conditioner drain lines shall be insulated as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.1.2 Equipment and Installation

Provide frames and supports for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Floor mount or ceiling hang air handling units as indicated. The method of anchoring and fastening shall be as detailed. Set floor-mounted equipment on not less than 6 inch concrete pads or curbs doweled in place unless otherwise indicated. Concrete foundations for circulating pumps shall be heavy enough to minimize the intensity of the vibrations transmitted to the piping and the surrounding structure, as recommended in writing by the pump manufacturer. In lieu of a concrete pad foundation, a concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. The concrete foundation or concrete pedestal block shall be of a mass not less than three times the weight of the components to be supported. Lines connected to the pump mounted on pedestal blocks shall be provided with flexible connectors. Furnish foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.1.3 Access Panels

Install access panels for concealed valves, vents, controls, dampers, and

items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05 50 00 METAL: MISCELLANEOUS AND FABRICATIONS.

3.1.4 Flexible Duct

Install pre-insulated flexible duct in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the duct, shall be of the type recommended by the duct manufacturer and shall be provided at the intervals recommended.

3.1.5 Metal Ductwork

Installation shall be according to SMACNA HVAC Duct Const Stds unless otherwise indicated. Duct supports for sheet metal ductwork shall be according to SMACNA HVAC Duct Const Stds, unless otherwise specified. Friction beam clamps indicated in SMACNA HVAC Duct Const Stds shall not be used. Risers on high velocity ducts shall be anchored in the center of the vertical run to allow ends of riser to move due to thermal expansion. Supports on the risers shall allow free vertical movement of the duct. Supports shall be attached only to structural framing members and concrete slabs. Supports shall not be anchored to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members, suitable intermediate metal framing shall be provided. Where C-clamps are used, retainer clips shall be provided.

3.1.6 Acoustical Duct Lining

Lining shall be applied in cut-to-size pieces attached to the interior of the duct with nonflammable fire resistant adhesive conforming to ASTM C 916, Type I, NFPA 90A, UL 723, and ASTM E 84. Top and bottom pieces shall lap the side pieces and shall be secured with welded pins, adhered clips of metal, nylon, or high impact plastic, and speed washers or welding cup-head pins installed according to SMACNA HVAC Duct Const Stds. Welded pins, cup-head pins, or adhered clips shall not distort the duct, burn through, nor mar the finish or the surface of the duct. Pins and washers shall be flush with the surfaces of the duct liner and all breaks and punctures of the duct liner coating shall be sealed with the nonflammable, fire resistant adhesive. Exposed edges of the liner at the duct ends and at other joints where the lining will be subject to erosion shall be coated with a heavy brush coat of the nonflammable, fire resistant adhesive, to prevent delamination of glass fibers. Duct liner may be applied to flat sheet metal prior to forming duct through the sheet metal brake. Lining at the top and bottom surfaces of the duct shall be additionally secured by welded pins or adhered clips as specified for cut-to-size pieces. Other methods indicated in SMACNA HVAC Duct Const Stds to obtain proper installation of duct liners in sheet metal ducts, including adhesives and fasteners, will be acceptable.

3.1.7 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, temporary dust control protection shall be provided. The distribution system (supply and return) shall be protected with temporary seal-offs at all inlets and outlets at the end of each day's work. Temporary protection shall remain in place until system is ready for startup.

3.1.8 Insulation

Thickness and application of insulation materials for ductwork, piping, and equipment shall be according to Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Outdoor air intake ducts and plenums shall be externally insulated up to the point where the outdoor air reaches the conditioning unit.

3.1.9 Duct Test Holes

Holes with closures or threaded holes with plugs shall be provided in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Extensions, complete with cap or plug, shall be provided where the ducts are insulated.

3.1.10 Power Transmission Components Adjustment

V-belts and sheaves shall be tested for proper alignment and tension prior to operation and after 72 hours of operation at final speed. Belts on drive side shall be uniformly loaded, not bouncing. Alignment of direct driven couplings shall be to within 50 percent of manufacturer's maximum allowable range of misalignment.

3.2 PENETRATIONS

Provide sleeves and prepared openings for duct mains, branches, and other penetrating items, and install during the construction of the surface to be penetrated. Cut sleeves flush with each surface. Provide sleeves for round duct 15 inches and smaller. Provide framed prepared openings for round duct larger than 15 inches and square, rectangular or oval ducts. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Provide one inch clearance between penetrating and penetrated surfaces except at grilles, registers, and diffusers. Pack spaces between sleeve or opening and duct or duct insulation with mineral fiber conforming with ASTM C 553, Type 1, Class B-2.

a. Sleeves: Fabricate sleeves, except as otherwise specified or indicated, from 20 gauge thick mill galvanized sheet metal. Where sleeves are installed in bearing walls or partitions, provide black steel pipe conforming with ASTM A 53/A 53M, Schedule 20.

b. Framed Prepared Openings: Fabricate framed prepared openings from 20 gauge galvanized steel, unless otherwise indicated.

c. Insulation: Provide duct insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS continuous through sleeves and prepared openings except firewall penetrations. Terminate duct insulation at fire dampers and flexible connections. For duct handling air at or below 60 degrees F, provide insulation continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air.

d. Closure Collars: Provide closure collars of a minimum 4 inches wide, unless otherwise indicated, for exposed ducts and items on each side of penetrated surface, except where equipment is installed. Install collar tight against the surface and fit snugly around the duct or insulation. Grind sharp edges smooth to prevent damage to penetrating surface. Fabricate collars for round ducts 15 inches in

diameter or less from 20 gauge galvanized steel. Fabricate collars for square and rectangular ducts, or round ducts with minimum dimension over 15 inches from 18 gauge galvanized steel. Fabricate collars for square and rectangular ducts with a maximum side of 15 inches or less from 20 gauge galvanized steel. Install collars with fasteners a maximum of 6 inches on center. Attach to collars a minimum of 4 fasteners where the opening is 12 inches in diameter or less, and a minimum of 8 fasteners where the opening is 20 inches in diameter or less.

e. Firestopping: Where ducts pass through fire-rated walls, fire partitions, and fire rated chase walls, seal the penetration with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING.

3.3 FIELD PAINTING AND IDENTIFICATION SYSTEMS

3.3.1 Identification Tags

Provide identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and item number on all valves and dampers. Tags shall be 1-3/8 inch minimum diameter and marking shall be stamped or engraved. Indentations shall be black for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.3.2 Finish Painting

The requirements for finish painting of items only primed at the factory, and surfaces not specifically noted otherwise, are specified in Section 09 90 00 PAINTS AND COATINGS.

3.3.3 Color Coding Scheme for Locating Hidden Utility Components

Use scheme in buildings having suspended grid ceilings. The color coding scheme shall identify points of access for maintenance and operation of components and equipment that are not visible from the finished space and are accessible from the ceiling grid. The color coding scheme shall consist of a color code board and colored metal disks. Each colored metal disk shall be approximately 3/8 inch diameter and secured to removable ceiling panels with fasteners. Insert each fastener into the ceiling panel so as to be concealed from view. The fasteners shall be manually removable without the use of tools and shall not separate from the ceiling panels when the panels are dropped from ceiling height. Installation of colored metal disks shall follow completion of the finished surface on which the disks are to be fastened. The color code board shall be approximately 3 foot wide, 30 inches high, and 1/2 inches thick. The board shall be made of wood fiberboard and framed under glass or 1/16 inch transparent plastic cover. The color code symbols shall be approximately 3/4 inch in diameter and the related lettering in 1/2 inch high capital letters.

3.4 DUCTWORK LEAK TEST

Perform ductwork leak test for the entire air distribution and exhaust system, including fans, coils Test procedure, apparatus, and report shall conform to SMACNA Leakage Test Mnl. Ductwork leak test shall be completed with satisfactory results prior to applying insulation to ductwork exterior.

3.5 DAMPER ACCEPTANCE TEST

Operate all fire dampers and smoke dampers under normal operating conditions, prior to the occupancy of a building to determine that they function properly. Test each fire damper equipped with fusible link by having the fusible link cut in place. Test dynamic fire dampers with the air handling and distribution system running. Reset all fire dampers with the fusible links replaced after acceptance testing. To ensure optimum operation and performance, install the damper so it is square and free from racking.

3.6 TESTING, ADJUSTING, AND BALANCING

The requirements for testing, adjusting, and balancing are specified in Section 23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Testing, adjusting, and balancing shall begin only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.7 PERFORMANCE TESTS

After testing, adjusting, and balancing is complete as specified, test each system as a whole to see that all items perform as integral parts of the system and temperatures and conditions are evenly controlled throughout the building. Make corrections and adjustments as necessary to produce the conditions indicated or specified. Capacity tests and general operating tests shall be conducted by an experienced engineer. Tests shall cover a period of not less than 180 days for each system and shall demonstrate that the entire system is functioning according to the specifications. Make coincidental chart recordings at points indicated on the drawings for the duration of the time period and record the temperature at space thermostats or space sensors, the humidity at space humidistats or space sensors and the ambient temperature and humidity in a shaded and weather protected area.

3.8 CLEANING AND ADJUSTING

Provide a temporary bypass for water coils to prevent flushing water from passing through coils. Inside of air terminal units, ducts, plenums, and casing shall be thoroughly cleaned of debris and blown free of small particles of rubbish and dust and then shall be vacuum cleaned before installing outlet faces. Wipe equipment clean, with no traces of oil, dust, dirt, or paint spots. Temporary filters shall be provided prior to startup of all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. Maintain system in this clean condition until final acceptance. Properly lubricate bearings with oil or grease as recommended by the manufacturer. Tighten belts to proper tension. Adjust control valves and other miscellaneous equipment requiring adjustment to setting indicated or directed. Adjust fans to the speed indicated by the manufacturer to meet specified conditions.

3.9 OPERATION AND MAINTENANCE TRAINING

The Contractor shall conduct a training course for the members of the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 20 hours of normal working time and shall start after all work specified herein is functionally completed and the Performance Tests have been approved. The field instruction shall

cover all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations. Notify the Contracting Officer at least 14 days prior to the date of proposed conduct of the training course.

-- End of Section --

SECTION 23 03 00.00 20

BASIC MECHANICAL MATERIALS AND METHODS
01/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B 117	(2007a) Standing Practice for Operating Salt Spray (Fog) Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007; Errata 2007; INT 2008) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2007) Standard for Motors and Generators
NEMA MG 10	(2001; R 2007) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2007) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2007; AMD 1 2008) National Electrical Code - 2008 Edition

1.2 RELATED REQUIREMENTS

This section applies to all sections of Divisions: 21, FIRE SUPPRESSION; 22, PLUMBING; and 23, HEATING, VENTILATING, AND AIR CONDITIONING of this project specification, unless specified otherwise in the individual section.

1.3 QUALITY ASSURANCE

1.3.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. Standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.3.2 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.3.3 Service Support

The equipment items shall be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3.4 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.3.5 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.3.5.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.3.5.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace

damaged or defective items.

1.5 ELECTRICAL REQUIREMENTS

Furnish motors, controllers, disconnects and contactors with their respective pieces of equipment. Motors, controllers, disconnects and contactors shall conform to and have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Furnish internal wiring for components of packaged equipment as an integral part of the equipment. Extended voltage range motors will not be permitted. Controllers and contactors shall have a maximum of 120 volt control circuits, and shall have auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of additional electrical service and related work shall be included under the section that specified that motor or equipment. Power wiring and conduit for field installed equipment shall be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.6 ELECTRICAL INSTALLATION REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.6.1 New Work

Provide electrical components of mechanical equipment, such as motors, motor starters (except starters/controllers which are indicated as part of a motor control center), control or push-button stations, float or pressure switches, solenoid valves, integral disconnects, and other devices functioning to control mechanical equipment, as well as control wiring and conduit for circuits rated 100 volts or less, to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors shall not be permitted. The interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit, the motor control equipment forming a part of motor control centers, and the electrical power circuits shall be provided under Division 26, except internal wiring for components of package equipment shall be provided as an integral part of the equipment. When motors and equipment furnished are larger than sizes indicated, provide any required changes to the electrical service as may be necessary and related work as a part of the work for the section specifying that motor or equipment.

1.6.2 High Efficiency Motors

1.6.2.1 High Efficiency Single-Phase Motors

Unless otherwise specified, single-phase fractional-horsepower alternating-current motors shall be high efficiency types corresponding to the applications listed in NEMA MG 11.

1.6.2.2 High Efficiency Polyphase Motors

Unless otherwise specified, polyphase motors shall be selected based on high efficiency characteristics relative to the applications as listed in NEMA MG 10. Additionally, polyphase squirrel-cage medium induction motors with continuous ratings shall meet or exceed energy efficient ratings in accordance with Table 12-6C of NEMA MG 1.

1.6.3 Three-Phase Motor Protection

Provide controllers for motors rated one one horsepower and larger with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

1.7 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.8 ACCESSIBILITY

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 PAINTING OF NEW EQUIPMENT

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

3.1.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test. Salt-spray fog test shall be in accordance with ASTM B 117, and for that test the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shall show no signs of rust creepage beyond 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment

shall not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system shall be designed for the temperature service.

3.1.2 Shop Painting Systems for Metal Surfaces

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F shall be cleaned to bare metal.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat.

b. Temperatures Between 120 and 400 Degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F shall receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.

c. Temperatures Greater Than 400 Degrees F: Metal surfaces subject to temperatures greater than 400 degrees F shall receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

-- End of Section --

SECTION 23 05 48.00 40

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
06/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S3.29	(1983; R 2001) Evaluation of Human Exposure to Vibration in Buildings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE HA IP	(2007) HVAC Applications Handbook, I-P Edition

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB Procedural Standards	(1994) Procedural Standards for Measuring Sound and Vibration

1.2 GENERAL REQUIREMENTS

All vibration-control apparatus shall be the product of a single manufacturing source, where possible. Human exposure levels should be considered using ANSI S3.29 and NEBB Procedural Standards.

Scheduled isolation mounting is in inches and is a minimum static deflection.

Spans referred to in Part 2, "Vibration-Isolation Systems Application," shall mean longest bay dimension.

Exact mounting sizes and number of isolators shall be determined by the isolator manufacturer based on equipment that will be installed. Equipment revolutions per minute (rpm) and spring deflections shall be checked to verify that resonance cannot occur.

Installation Drawings for vibration isolator systems shall include equipment and performance requirements.

Outline Drawings for vibration isolator systems shall indicate overall physical features, dimensions, ratings, service requirements, and weights of equipment.

Equipment and Performance Data for vibration isolator systems shall include equipment base design; inertia-block mass relative to support equipment weight; spring loads and free, operating, and solid heights of spring; spring diameters; nonmetallic isolator loading and deflection; disturbing frequency; natural frequency of mounts; deflection of working member; and

anticipated amount of physical movement at the reference points.

Mount all overhead utilities and other equipment weighing 31 pounds or more with bracing in accordance with AT/FP criteria. Design all equipment mountings to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings and Outline Drawings shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

SD-03 Product Data

Equipment and Performance Data shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

Manufacturer's catalog data shall be submitted for the following items:

Mountings; G, DO
Bases; G, DO
Isolators; G, DO
Floor-Mounted Piping; G, DO
Vertical Piping; G, DO

SD-06 Test Reports

Test reports shall be submitted for deflection tests in accordance with the paragraph entitled, "Type of Vibration-Isolation Provisions," of this section. Reports shall include the following information:

Type of Isolator
Type of Base
Allowable Deflection
Measured Deflection

PART 2 PRODUCTS

2.1 TYPE OF VIBRATION-ISOLATION PROVISIONS

Design for vibration isolation using ASHRAE HA IP, Chapter 47, as applicable to the following sections.

Test reports for deflection tests shall be submitted for each Type of Isolator and each Type of Base, and meet referenced standards contained within this section. Test reports shall also include Allowable Deflection and Measured Deflection also meeting referenced standards within this section.

2.1.1 Materials

Rubber shall be natural rubber. Elastomer shall be chloroprene. Shore A durometer measurement of both materials shall range between 40 and 60.

Inorganic materials such as precompressed, high-density, fibrous glass encased in a resilient moisture-impervious membrane may be used in lieu of specified natural rubber and elastomers. Where this substitution is made, specified deflections shall be modified by the manufacturing source to accommodate physical characteristics of inorganic materials and to provide equal or better vibration isolation.

Weather-exposed metal vibration-isolator parts shall be corrosion protected. Springs shall be chloroprene coated.

2.1.2 Mountings

Mountings shall be:

Type A: Composite pad, with 0.25-inch thick elastomer top and bottom layers, molded to contain a pattern with nonslip characteristics in all horizontal directions. Elastomer loading shall not exceed 40 pounds per square inch (psi). Minimum overall thickness shall be 1 inch. Maximum deflections up to 0.25-inch are allowed.

Type B: Double rubber-in-shear elastomer-in-shear with molded-in steel reinforcement in top and bottom. Maximum deflections up to 0.50 inch are allowed.

Type C: Free-standing laterally stable open-spring type for deflections over 0.50 inch, with built-in bearing and leveling provisions, 0.25-inch thick Type A base elastomer pads, and accessories. Outside diameter of each spring shall be equal to or greater than 0.9 times the operating height of the spring under rated load.

Type D: Partially housed type, containing one or more vertically restrained springs with at least 0.50 inchclearance maintained around springs, with adjustable limit stops, 0.25-inch thick Type A base elastomer pads, and accessories.

Type E: Pendulum-suspension configuration with free-standing stable spring with resilient horizontal and vertical restraints to allow maximum movements of 0.25 inch in each direction, 0.25-inch thick Type A base elastomer pads.

Type F: Combination spring and rubber-in-shear elastomer-in-shear steel framed for hanger-rod mounting. Minimum total static deflection shall be 1 inch.

2.1.3 Bases

Bases shall be:

Type U: Unit isolators without rails, structural-steel bases, or inertia blocks.

Type R: Rails, connected mill-rolled structural steel, of sufficient dimension to preclude deflection at midpoint of unsupported span in

excess of 1/1,440th of the span between isolators, power transmission, component misalignment, and any overhung weight. Where Type R bases are specified and the equipment proposed requires additional base support, a Type S base shall be used.

Type S: Structural-steel bases common to a supported assembly, made from welded-joint mill-rolled structural steel with closed-perimeter configuration, isolators attached to outrigger supports.

Height of steel members shall be sufficient to provide stiffness required to maintain equipment manufacturer's recommended alignment and duty efficiency of power-transmission components. Height of steel member shall not result in member deflection at midpoint of unsupported span of more than 1/1,440th of the span between isolators. Minimum height shall be 5 inches.

Type CIB: Concrete inertia blocks shall be common to the entire assembly, shall have welded-joint construction, mill-rolled structural-steel perimeters, welded-in No. 4 reinforcing bars 8 inches on center each way near the bottom of the block, outrigger-isolator mounting provisions, anchor bolts, and shall be filled with 3,000 psi cured-strength concrete.

Configuration of inertia bases shall be rectangular to accommodate equipment supported.

Minimum thickness of inertia base, in addition to providing suitable mass, shall be sufficient to provide stiffness to maintain equipment manufacturer's recommended alignment and duty efficiency of power-transmission components. Minimum thickness shall be sufficient to result in base deflection at midpoint of unsupported span of not more than 1/1,440th of the span between isolators. Minimum thickness, the preceding requirements not withstanding, shall be 8 percent of the longest base dimension.

Pumps with flexible couplings shall have inertia bases not less than 8 inches thick.

Minimum mass of concrete inertia block shall be equal in weight to supported equipment.

2.2 VIBRATION-ISOLATION SYSTEMS APPLICATION

Vibration isolation design per ASHRAE HA IP, Chapter 47.

2.2.1 Centrifugal Water Chiller Package Locations

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
Hermetic	A-U-0.25	B-U-0.50	D-S-1.75	D-S-2.5
Open Type	B-U-0.38	D-U-1.0	D-CIB-1.75	D-CIB-2.5

*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES

2.2.2 Centrifugal Pump Locations

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
Close-couple through 5 hp	None	-R-0.35	C-S-1.0	C-S-1.0
Bedplate-mounted through 5 hp	None	C-CIB-1.0	C-CIB-1.5	C-CIB-1.75
7-1/2 hp	None	C-CIB-1.0	C-CIB-1.75	C-CIB-2.5

*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES

2.2.3 Low-Pressure AHU Locations

Vibration-isolation provisions apply to floor-mounted Air Moving and Conditioning Association Class A packaged central-station units.

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
Through 5 hp	B-U-0.35	C-U-1.0	C-U-1.0	C-U-1.0
7-1/2 hp and over 250 to 500 rpm	B-U-0.35	C-U-1.75	C-U-1.75	C-U-1.75
500 rpm	B-U-0.35	C-U-1.0	C-U-1.5	

*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES

2.2.4 Medium- and High-Pressure AHU Locations

Vibration-isolation provisions apply to floor-mounted Air Moving and Conditioning Association Classes B and C packaged central-station units.

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
Through 20 hp 250 to 300 rpm	B-U-0.35	C-U-2.5	C-U-2.5	C-U-3.5
300 to				

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
500 rpm	B-U-0.35	C-U-1.75	C-U-1.75	C-U-2.5
500 rpm and over	B-U-0.35	C-U-1.0	C-U-1.0	C-U-1.75
Over 20 hp 250 to 300 rpm	B-U-0.35	C-U-2.5	C-CIB-3.5	C-CIB-3.5
300 to 500 rpm	B-U-0.35	C-U-2.5	C-CIB-2.5	C-CIB-3.5
500 rpm and over	B-U-0.35	C-U-1.0	C-CIB-1.75	C-CIB-2.5

*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES

2.2.5 Cross-Flow Cooling Tower Locations

TYPE EQUIPMENT	20-FOOT ROOF-SPAN PROVISIONS*	30-FOOT ROOF-SPAN PROVISIONS*	40-FOOT ROOF-SPAN PROVISIONS*
Package under tower base to 500 rpm	B-U-0.35	D-U-2.0	D-U-2.5
500 rpm and over	B-U-0.35	D-U-1.0	D-U-1.75
Field erected under tower base; all rpm			
Under mechanical-equipment supporting frame to 500 rpm			
500 rpm and over			

*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES

2.2.6 Blow-Through Cooling Tower Locations

TYPE EQUIPMENT	20-FOOT ROOF-SPAN PROVISIONS*	30-FOOT ROOF-SPAN PROVISIONS*	40-FOOT ROOF-SPAN PROVISIONS*
Under tower base to 500 rpm	B-U-0.35	C-S-2.5	C-S-3.5
500 rpm and over	B-U-0.35	C-S-1.0	C-S-1.75

*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES

TYPE EQUIPMENT	20-FOOT ROOF-SPAN PROVISIONS*	30-FOOT ROOF-SPAN PROVISIONS*	40-FOOT ROOF-SPAN PROVISIONS*

2.3 PIPE AND DUCT VIBRATION ISOLATION

Type G: Isolators shall be devices with in-series contained steel springs and preformed fibrous-glass or chloroprene-elastomer elements for connecting to building-structure attachments. Devices shall be loaded by supported system during operating conditions to produce a minimum spring and elastomer static deflection of 1 inch and 3/8 inch, respectively.

Type H: Isolators shall be devices with contained chloroprene-elastomer elements for connecting to building-structure attachments. Devices shall be loaded by supported system during operating conditions to produce a minimum elastomer static deflection of 3/8 inch.

Type J: Isolators shall be devices with elastomers mounted on floor-supported columns or directly on the floor. Devices shall be loaded by supported system during operating conditions to produce a minimum elastomer static deflection of 3/8 inch.

2.3.1 Floor-Mounted Piping

Type K: Isolators shall be devices with springs mounted on floor-supported columns or directly on the floor. Devices shall be loaded by supported system during operating conditions to produce a minimum spring static deflection of 1 inch.

2.3.2 Vertical Piping

Type L: Isolators shall be pipe base-support devices with one or more contained steel springs. Devices shall be loaded by supported system during operating conditions to produce a minimum static deflection of 1 inch. Devices shall be equipped with precompression and vertical-limit features, as well as a minimum 1/4-inch thick elastomer sound pad and isolation washers, for mounting to floor.

Type M: Isolators shall be elastomer mounted baseplate and riser pipe-guide devices. Elastomer elements shall be contained double acting, and elastomers under rated load shall have a minimum static deflection of 3/8 inch. Isolator shall be sized to accommodate thermal insulation within the stationary guide ring.

PART 3 EXECUTION

3.1 INSTALLATION

Equipment shall be installed in accordance with manufacturer's recommendations.

Rails, structural steel bases, and concrete inertia blocks shall be raised not less than 1 inch above the floor and shall be level when equipment supported is under operating load.

Vibration-isolation installation and deflection testing after equipment start-up shall be directed by a competent representative of the manufacturer.

3.2 TESTS AND REPORTS

Vibration-isolation devices shall be deflection tested. Test reports shall be submitted in accordance with paragraph entitled, "Submittal Procedures," substantiating that all equipment has been isolated as specified and that minimum specified deflections have been met. All measurements shall be made in the presence of the Contracting Officer.

-- End of Section --

SECTION 23 05 93.00 10

TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATED AIR BALANCE COUNCIL (AABC)

AABC MN-1	(2002) National Standards for Total System Balance

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB TABES	(2005) Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA HVACTAB	(2002, 3rd Ed) HVAC Systems - Testing, Adjusting and Balancing

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

TAB Schematic Drawings and Report Forms; G, DO

Three copies of the TAB Schematic Drawings and Report Forms, no later than 21 days prior to the start of TAB field measurements.

SD-03 Product Data

TAB Related HVAC Submittals

A list of the TAB Related HVAC Submittals, no later than 7 days after the approval of the TAB Specialist.

TAB Procedures; G, DO

Proposed procedures for TAB, submitted with the TAB Schematic Drawings and Report Forms.

Calibration

List of each instrument to be used during TAB, stating calibration requirements required or recommended by both the TAB Standard and the instrument manufacturer and the actual calibration history of the instrument, submitted with the TAB Procedures. The calibration history shall include dates calibrated, the qualifications of the calibration laboratory, and the calibration procedures used.

Systems Readiness Check

Proposed date and time to begin the Systems Readiness Check, no later than 7 days prior to the start of the Systems Readiness Check.

TAB Execution; G, DO

Proposed date and time to begin field measurements, making adjustments, etc., for the TAB Report, submitted with the Systems Readiness Check Report.

TAB Verification; G, DO

Proposed date and time to begin the TAB Verification, submitted with the TAB Report.

SD-06 Test Reports

Design Review Report; G

A copy of the Design Review Report, no later than 14 days after approval of the TAB Firm and the TAB Specialist.

A copy of completed checklists for each system, each signed by the TAB Specialist, at least 7 days prior to the start of TAB Execution. All items in the Systems Readiness Check Report shall be signed by the TAB Specialist and shall bear the seal of the Professional Society or National Association used as the TAB Standard.

TAB Report; G, DO

Three copies of the completed TAB Reports, no later that 7 days after the execution of TAB. All items in the TAB Report shall be signed by the TAB Specialist and shall bear the seal of the Professional Society or National Association used as the TAB Standard.

TAB Verification Report; G, DO

Three copies of the completed TAB Verification Report, no later that 7 days after the execution of TAB Verification. All items in the TAB Verification Report shall be signed by the TAB Specialist and shall bear the seal of the Professional Society or National Association used as the TAB Standard.

SD-07 Certificates

Ductwork Leak Testing

A written statement signed by the TAB Specialist certifying that the TAB Specialist witnessed the Ductwork Leak Testing, it was successfully completed, and that there are no known deficiencies related to the ductwork installation that will prevent TAB from producing satisfactory results.

TAB Firm; G, DO

Certification of the proposed TAB Firm's qualifications by either AABC, NEBB, or TABB to perform the duties specified herein and in other related Sections, no later than 21 days after the Notice to Proceed. The documentation shall include the date that the Certification was initially granted and the date that the current Certification expires. Any lapses in Certification of the proposed TAB Firm or disciplinary action taken by AABC, NEBB or TABB against the proposed TAB Firm shall be described in detail.

TAB Specialist; G, DO

Certification of the proposed TAB Specialist's qualifications by either AABC, NEBB, or TABB to perform the duties specified herein and in other related Sections, no later than 21 days after the Notice to Proceed. The documentation shall include the date that the Certification was initially granted and the date that the current Certification expires. Any lapses in Certification of the proposed TAB Specialist or disciplinary action taken by AABC, NEBB, or TABB against the proposed TAB Specialist shall be described in detail.

1.3 SIMILAR TERMS

In some instances, terminology differs between the Contract and the TAB Standard primarily because the intent of this Section is to use the industry standards specified, along with additional requirements listed herein to produce optimal results. The following table of similar terms is provided for clarification only. Contract requirements take precedent over the corresponding AABC, NEBB, or TABB requirements where differences exist.

SIMILAR TERMS

Contract Term	AABC Term	NEBB Term	TABB Term
TAB Standard	National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems	Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.	SMACNA's Procedures
TAB Specialist	TAB Engineer	TAB Supervisor	TAB Supervisor
Systems Readiness Check	Construction Phase Inspection	Field Readiness Check & Preliminary Field Procedures.	Field Readiness Check & Prelim. Field

SIMILAR TERMS

Procedures

1.4 TAB STANDARD

TAB shall be performed in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved, i.e., AABC MN-1, NEBB TABES, or SMACNA HVACTAB unless otherwise specified herein. All recommendations and suggested practices contained in the TAB Standard shall be considered mandatory. The provisions of the TAB Standard, including checklists, report forms, etc., shall, as nearly as practical, be used to satisfy the Contract requirements. The TAB Standard shall be used for all aspects of TAB, including qualifications for the TAB Firm and Specialist and calibration of TAB instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the TAB Standard, the manufacturer's recommendations shall be adhered to. All quality assurance provisions of the TAB Standard such as performance guarantees shall be part of this contract. For systems or system components not covered in the TAB Standard, TAB procedures shall be developed by the TAB Specialist. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the TAB Standard used (AABC, NEBB, or TABB), the requirements and recommendations contained in these procedures and requirements shall be considered mandatory.

1.5 QUALIFICATIONS

1.5.1 TAB Firm

The TAB Firm shall be either a member of AABC or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications, including TAB of environmental systems and the measuring of sound and vibration in environmental systems. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor shall immediately notify the Contracting Officer and submit another TAB Firm for approval. Any firm that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections to be performed by the TAB Firm shall be considered invalid if the TAB Firm loses its certification prior to Contract completion and must be performed by an approved successor. These TAB services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The TAB Firm shall be a subcontractor of the prime Contractor and shall be financially and corporately independent of the mechanical subcontractor, and shall report to and be paid by the prime Contractor.

1.5.2 TAB Specialist

The TAB Specialist shall be either a member of AABC,an experienced technician of the Firm certified by the NEBB, or a Supervisor certified by the TABB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the Contractor shall immediately notify the Contracting Officer and submit another TAB Specialist for approval.

Any individual that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB Specialist shall be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by the approved successor.

1.6 TAB SPECIALIST RESPONSIBILITIES

All TAB work specified herein and in related sections shall be performed under the direct guidance of the TAB Specialist. The TAB specialist is required to be onsite on a daily basis to direct TAB efforts. The TAB Specialist shall participate in the commissioning process specified in Section 23 08 00.00 10 COMMISSIONING OF HVAC SYSTEMS.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 DESIGN REVIEW

The TAB Specialist shall review the Contract Plans and Specifications and advise the Contracting Officer of any deficiencies that would prevent the effective and accurate TAB of the system. The TAB Specialist shall provide a Design Review Report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

3.2 TAB RELATED HVAC SUBMITTALS

The TAB Specialist shall prepare a list of the submittals from the Contract Submittal Register that relate to the successful accomplishment of all HVAC TAB. The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the TAB Specialist when submitted to the Government. The TAB Specialist shall also ensure that the location and details of ports, terminals, connections, etc., necessary to perform TAB are identified on the submittals.

3.3 TAB SCHEMATIC DRAWINGS AND REPORT FORMS

A schematic drawing showing each system component, including balancing devices, shall be provided for each system. Each drawing shall be accompanied by a copy of all report forms required by the TAB Standard used for that system. Where applicable, the acceptable range of operation or appropriate setting for each component shall be included on the forms or as an attachment to the forms. The schematic drawings shall identify all testing points and cross reference these points to the report forms and procedures.

3.4 DUCTWORK LEAK TESTING

The TAB Specialist shall witness the Ductwork Leak Testing specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM and approve the results as specified in Paragraph TAB RELATED HVAC SUBMITTALS.

3.5 TESTING, ADJUSTING, AND BALANCING

3.5.1 TAB Procedures

Step by step procedures for each measurement required during TAB Execution shall be provided. The procedures shall be oriented such that there is a separate section for each system. The procedures shall include measures to ensure that each system performs as specified in all operating modes, interactions with other components (such as exhaust fans, kitchen hoods, fume hoods, relief vents, etc.) and systems, and with all seasonal operating differences, diversity, simulated loads, and pressure relationships required.

3.5.2 Systems Readiness Check

The TAB Specialist shall inspect each system to ensure that it is complete, including installation and operation of controls, and that all aspects of the facility that have any bearing on the HVAC systems, including installation of ceilings, walls, windows, doors, and partitions, are complete to the extent that TAB results will not be affected by any detail or touch-up work remaining. The TAB Specialist shall also verify that all items such as ductwork and piping ports, terminals, connections, etc., necessary to perform TAB shall be complete during the Systems Readiness Check.

3.5.3 Preparation of TAB Report

Preparation of the TAB Report shall begin only when the Systems Readiness Report has been approved. The Report shall be oriented so that there is a separate section for each system. The Report shall include a copy of the appropriate approved Schematic Drawings and TAB Related Submittals, such as pump curves, fan curves, etc., along with the completed report forms for each system. The operating points measured during successful TAB Execution and the theoretical operating points listed in the approved submittals shall be marked on the performance curves and tables. Where possible, adjustments shall be made using an "industry standard" technique which would result in the greatest energy savings, such as adjusting the speed of a fan instead of throttling the flow. Any deficiencies outside of the realm of normal adjustments and balancing during TAB Execution shall be noted along with a description of corrective action performed to bring the measurement into the specified range. If, for any reason, the TAB Specialist determines during TAB Execution that any Contract requirement cannot be met, the TAB Specialist shall immediately provide a written description of the deficiency and the corresponding proposed corrective action necessary for proper system operation to the Contracting Officer.

3.5.4 TAB Verification

The TAB Specialist shall recheck ten percent of the measurements listed in the Tab Report and prepare a TAB Verification Report. The measurements selected for verification and the individuals that witness the verification will be selected by the Contracting Officer's Representative (COR). The measurements will be recorded in the same manner as required for the TAB Report. All measurements that fall outside the acceptable operating range specified shall be accompanied by an explanation as to why the measurement does not correlate with that listed in the TAB Report and a description of corrective action performed to bring the measurement into the specified range. The TAB Specialist shall update the original TAB report to reflect any changes or differences noted in the TAB verification report and submit

the updated TAB report. If over 20 percent of the measurements selected by the COR for verification fall outside of the acceptable operating range specified, the COR will select an additional ten percent for verification. If over 20 percent of the total tested (including both test groups) fall outside of the acceptable range, the TAB Report shall be considered invalid and all contract TAB work shall be repeated beginning with the Systems Readiness Check.

3.5.5 Marking of Setting

Following approval of TAB Verification Report, the setting of all HVAC adjustment devices including valves, splitters, and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time.

3.5.6 Identification of Test Ports

The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leakage or to maintain integrity of vapor barrier.

-- End of Section --

SECTION 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS
01/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. At the discretion of the Government, the manufacturer of any material supplied will be required to furnish test reports pertaining to any of the tests necessary to assure compliance with the standard or standards referenced in this specification.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2007; Errata 2008; Errata 2008; Errata 2008) Energy Standard for Buildings Except Low-Rise Residential Buildings, I-P Edition

ASTM INTERNATIONAL (ASTM)

ASTM A 167	(1999; R 2004) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 240/A 240M	(2007e1) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A 580/A 580M	(2008) Standard Specification for Stainless Steel Wire
ASTM B 209	(2007) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM C 1126	(2004) Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
ASTM C 1136	(2006) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C 1290	(2006) Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts
ASTM C 195	(2000) Standard Specification for Mineral Fiber Thermal Insulating Cement
ASTM C 449/C 449M	(2000) Standard Specification for Mineral

	Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
ASTM C 533	(2007) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C 534	(2007a) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C 547	(2007) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C 552	(2007) Standard Specification for Cellular Glass Thermal Insulation
ASTM C 553	(2002) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C 591	(2007) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C 610	(2007) Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation
ASTM C 612	(2004) Mineral Fiber Block and Board Thermal Insulation
ASTM C 647	(1995; R 2000) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM C 665	(2006) Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing
ASTM C 795	(2003) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM C 916	(1985; R 2001e1) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C 920	(2008) Standard Specification for Elastomeric Joint Sealants
ASTM C 921	(2003a) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM D 774/D 774M	(1997; R 2002) Bursting Strength of Paper
ASTM D 882	(2002) Tensile Properties of Thin Plastic Sheeting

ASTM E 2231	(2007) Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics
ASTM E 84	(2008a) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E 96/E 96M	(2005) Standard Test Methods for Water Vapor Transmission of Materials

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-69	(2003; R 2004) Standard for Pipe Hangers and Supports - Selection and Application

MIDWEST INSULATION CONTRACTORS ASSOCIATION (MICA)

MICA Insulation Stds	(1999) National Commercial & Industrial Insulation Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 255	(2005; Errata 2006) Standard Method of Test of Surface Burning Characteristics of Building Materials

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-3316	(Rev C; Am 2) Adhesives, Fire-Resistant, Thermal Insulation

UNDERWRITERS LABORATORIES (UL)

UL 723	(2008) Standard for Test for Surface Burning Characteristics of Building Materials

1.2 SYSTEM DESCRIPTION

Field-applied insulation and accessories on mechanical systems shall be as specified herein; factory-applied insulation is specified under the piping, duct or equipment to be insulated. Insulation of heat distribution systems and chilled water systems outside of buildings shall be as specified in Section 33 61 00 PREFABRICATED UNDERGROUND HEATING/COOLING DISTRIBUTION SYSTEM . Field applied insulation materials required for use on Government-furnished items as listed in the SPECIAL CONTRACT REQUIREMENTS shall be furnished and installed by the Contractor.

1.3 GENERAL QUALITY CONTROL

1.3.1 Industry Standards

Provide insulation systems in accordance with the approved MICA National Insulation Standards plates as supplemented by this specification.

1.3.2 Standard Products

Provide field-applied insulation for heating, ventilating, and cooling (HVAC) air distribution systems and piping systems which are located within, on, under, and adjacent to buildings; and for plumbing systems. Materials shall be the standard products of manufacturers regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.3.3 Installer's Qualifications

Qualified installers shall have successfully completed three or more similar type jobs within the last 5 years.

1.3.4 Surface Burning Characteristics

Unless otherwise specified, insulation shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E 84. Flame spread, and smoke developed indexes, shall be determined by ASTM E 84, NFPA 255 or UL 723. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Test specimens shall be prepared and mounted according to ASTM E 2231. Insulation materials located exterior to the building perimeter are not required to be fire rated.

1.3.5 Identification of Materials

Packages or standard containers of insulation, jacket material, cements, adhesives, and coatings delivered for use, and samples required for approval shall have manufacturer's stamp or label attached giving the name of the manufacturer and brand, and a description of the material. Insulation packages and containers shall be asbestos free.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

Submit the three SD types, SD-02 Shop Drawings, SD-03 Product Data, and SD-08 Manufacturer's Instructions at the same time for each system.

SD-02 Shop Drawings

MICA Plates; G, DO
Pipe Insulation Systems and Associated Accessories
Duct Insulation Systems and Associated Accessories
Equipment Insulation Systems and Associated Accessories

After approval of materials and prior to applying insulation, submit a booklet containing completed MICA Insulation Stds plates detailing each insulating system for each pipe, duct, or equipment insulating system.

a. The MICA plates shall detail the materials to be installed the specific insulation application. Submit all MICA plates

required showing the entire insulating system, including plates required to show insulation penetrations, vessel bottom and top heads, legs, and skirt insulation as applicable. The MICA plates shall present all variations of insulation systems including locations, materials, vaporproofing, jackets and insulation accessories.

b. If the Contractor elects to submit detailed drawings instead of edited MICA Plates, the detail drawings shall be technically equivalent to the edited MICA Plate submittal.

SD-03 Product Data

Pipe Insulation Systems; G, DO
Duct Insulation Systems; G, DO
Equipment Insulation Systems; G, DO

A complete list of materials, including manufacturer's descriptive technical literature, performance data, catalog cuts, and installation instructions. The product number, k-value, thickness and furnished accessories including adhesives, sealants and jackets for each mechanical system requiring insulation shall be included. The product data must be copywrited, have an identifying or publication number, and shall have been published prior to the issuance date of this solicitation. Materials furnished under this section of the specification shall be submitted together in a booklet and in conjunction with the MICA plates booklet (SD-02). Annotate the product data to indicate which MICA plate is applicable.

1.5 STORAGE

Materials shall be delivered in the manufacturer's unopened containers. Materials delivered and placed in storage shall be provided with protection from weather, humidity, dirt, dust and other contaminants. The Contracting Officer may reject insulation material and supplies that become dirty, dusty, wet, or contaminated by some other means.

1.6 RECYCLED MATERIALS

Provide thermal insulation containing recycled materials to the extent practicable, provided that the materials meets all other requirements of this section. The minimum recycled material content of the following insulation are:

Rock Wool - 75 percent slag of weight
Fiberglass - 20-25 percent glass cullet by weight
Rigid Foam - 9 percent recovered material

PART 2 PRODUCTS

2.1 GENERAL MATERIALS

Provide insulation that meets or exceed the requirements of ASHRAE 90.1 - IP. Insulation exterior shall be cleanable, grease resistant, non-flaking and non-peeling. Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either wet or dry state. Materials to be used on stainless steel surfaces shall meet ASTM C 795 requirements. Materials shall be asbestos free and conform

to the following:

2.1.1 Adhesives

2.1.1.1 Acoustical Lining Insulation Adhesive

Adhesive shall be a nonflammable, fire-resistant adhesive conforming to ASTM C 916, Type I.

2.1.1.2 Mineral Fiber Insulation Cement

Cement shall be in accordance with ASTM C 195.

2.1.1.3 Lagging Adhesive

Lagging is the material used for thermal insulation, especially around a cylindrical object. This may include the insulation as well as the cloth/material covering the insulation. Lagging adhesives shall be nonflammable and fire-resistant and shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E 84. Adhesive shall be MIL-A-3316, Class 1, pigmented white or red and be suitable for bonding fibrous glass cloth to faced and unfaced fibrous glass insulation board; for bonding cotton brattice cloth to faced and unfaced fibrous glass insulation board; for sealing edges of and bonding glass tape to joints of fibrous glass board; for bonding lagging cloth to thermal insulation; or Class 2 for attaching fibrous glass insulation to metal surfaces. Lagging adhesives shall be applied in strict accordance with the manufacturer's recommendations for pipe and duct insulation.

2.1.2 Contact Adhesive

Adhesives may be any of, but not limited to, the neoprene based, rubber based, or elastomeric type that have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E 84. The adhesive shall not adversely affect, initially or in service, the insulation to which it is applied, nor shall it cause any corrosive effect on metal to which it is applied. Any solvent dispersing medium or volatile component of the adhesive shall have no objectionable odor and shall not contain any benzene or carbon tetrachloride. The dried adhesive shall not emit nauseous, irritating, or toxic volatile matters or aerosols when the adhesive is heated to any temperature up to 212 degrees F. The dried adhesive shall be nonflammable and fire resistant. Natural cross-ventilation, local (mechanical) pickup, and/or general area (mechanical) ventilation shall be used to prevent an accumulation of solvent vapors, keeping in mind the ventilation pattern must remove any heavier-than-air solvent vapors from lower levels of the workspaces. Gloves and spectacle-type safety glasses are recommended in accordance with safe installation practices.

2.1.3 Caulking

ASTM C 920, Type S, Grade NS, Class 25, Use A.

2.1.4 Corner Angles

Nominal 0.016 inch aluminum 1 by 1 inch with factory applied kraft backing. Aluminum shall be ASTM B 209, Alloy 3003, 3105, or 5005.

2.1.5 Finishing Cement

ASTM C 449/C 449M: Mineral fiber hydraulic-setting thermal insulating and finishing cement. All cements that may come in contact with Austenitic stainless steel must comply with ASTM C 795.

2.1.6 Fibrous Glass Cloth and Glass Tape

Fibrous glass cloth, with 20X20 maximum mesh size, and glass tape shall have maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E 84. Tape shall be 4 inch wide rolls. Class 3 tape shall be 4.5 ounces/square yard.

2.1.7 Staples

Outward clinching type ASTM A 167, Type 304 or 316 stainless steel.

2.1.8 Jackets

2.1.8.1 Aluminum Jackets

Aluminum jackets shall be corrugated, embossed or smooth sheet, 0.016 inch nominal thickness; ASTM B 209, Temper H14, Temper H16, Alloy 3003, 5005, or 3105. Corrugated aluminum jacket shall not be used outdoors. Aluminum jacket securing bands shall be Type 304 stainless steel, 0.015 inch thick, 1/2 inch wide for pipe under 12 inch diameter and 3/4 inch wide for pipe over 12 inch and larger diameter. Aluminum jacket circumferential seam bands shall be 2 by 0.016 inch aluminum matching jacket material. Bands for insulation below ground shall be 3/4 by 0.020 inch thick stainless steel, or fiberglass reinforced tape. The jacket may, at the option of the Contractor, be provided with a factory fabricated Pittsburgh or "Z" type longitudinal joint. When the "Z" joint is used, the bands at the circumferential joints shall be designed by the manufacturer to seal the joints and hold the jacket in place.

2.1.8.2 Polyvinyl Chloride (PVC) Jackets

Polyvinyl chloride (PVC) jacket and fitting covers shall have high impact strength, UV resistant rating or treatment and moderate chemical resistance with minimum thickness 0.030 inch.

2.1.8.3 Vapor Barrier/Weatherproofing Jacket

Vapor barrier/weatherproofing jacket shall be laminated self-adhesive, greater than 3 plys standard grade, silver, white, black and embossed or greater than 8 ply (minimum 2.9 mils adhesive); with 0.0000 permeability when tested per ASTM E 96/E 96M; heavy duty, white or natural; and UV resistant.

2.1.9 Vapor Retarder Required

ASTM C 921, Type I, minimum puncture resistance 50 Beach units on all surfaces except concealed ductwork, where a minimum puncture resistance of 25 Beach units is acceptable. Minimum tensile strength, 35 pounds/inch width. ASTM C 921, Type II, minimum puncture resistance 25 Beach units, tensile strength minimum 20 pounds/inch width. Jackets used on insulation exposed in finished areas shall have white finish suitable for painting without sizing. Based on the application, insulation materials that require factory applied jackets are mineral fiber, cellular glass,

polyisocyanurate, and phenolic foam. Insulation materials that do not require jacketing are flexible elastomerics. All non-metallic jackets shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E 84.

2.1.9.1 White Vapor Retarder All Service Jacket (ASJ)

Standard reinforced fire retardant jacket for use on hot/cold pipes, ducts, or equipment. Vapor retarder jackets used on insulation exposed in finished areas shall have white finish suitable for painting without sizing.

2.1.9.2 Vapor Retarder/Vapor Barrier Mastic Coatings

a. The vapor barrier shall be self adhesive (minimum 2 mils adhesive, 3 mils embossed) greater than 3 plys standard grade, silver, white, black and embossed white jacket for use on hot/cold pipes. Less than 0.02 permeability when tested per ASTM E 96/E 96M. Meeting UL 723 or ASTM E 84 flame and smoke requirements; UV resistant.

b. The vapor retarder coating shall be fire and water resistant and appropriately selected for either outdoor or indoor service. Color shall be white. The water vapor permeance of the compound shall be determined according to procedure B of ASTM E 96/E 96M utilizing apparatus described in ASTM E 96/E 96M. The coating shall be a nonflammable, fire resistant type. All other application and service properties shall be in accordance with ASTM C 647.

2.1.9.3 Laminated Film Vapor Retarder

ASTM C 1136, Type I, maximum moisture vapor transmission 0.02 perms, minimum puncture resistance 50 Beach units on all surfaces except concealed ductwork, where Type II, maximum moisture vapor transmission 0.02 perms, a minimum puncture resistance of 25 Beach units is acceptable. Vapor retarder shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E 84.

2.1.9.4 Polyvinylidene Chloride (PVDC) Film Vapor Retarder

The PVDC film vapor retarder shall have a maximum moisture vapor transmission of 0.02 perms, minimum puncture resistance of 150 Beach units, a minimum tensile strength in any direction of 30 lb/inch when tested per ASTM D 882, and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E 84.

2.1.9.5 Polyvinylidene Chloride Vapor Retarder Adhesive Tape

Requirements must meet the same as specified for Laminated Film Vapor Retarder above.

2.1.9.6 Vapor Barrier

The vapor barrier shall be greater than 3 ply self adhesive laminate -white vapor barrier jacket- superior performance (less than 0.0000 permeability when tested per ASTM E 96/E 96M). Vapor barrier shall meet UL 723 or ASTM E 84 25 flame and 50 smoke requirements; and UV resistant. Minimum burst strength 185 psi per ASTM D 774/D 774M. Tensile strength 68 lb/inch width (PSTC-1000). Tape shall be as specified for laminated film vapor barrier above.

2.1.10 Vapor Retarder Not Required

ASTM C 921, Type II, Class D, minimum puncture resistance 50 Beach units on all surfaces except ductwork, where Type IV, maximum moisture vapor transmission 0.10, a minimum puncture resistance of 25 Beach units is acceptable. Jacket shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E 84.

2.1.11 Wire

Soft annealed ASTM A 580/A 580M Type 302, 304 or 316 stainless steel, 16 or 18 gauge.

2.1.12 Insulation Bands

Insulation bands shall be 1/2 inch wide; 26 gauge stainless steel.

2.1.13 Sealants

Sealants shall be chosen from the butyl polymer type, the styrene-butadiene rubber type, or the butyl type of sealants. Sealants shall have a maximum moisture vapor transmission of 0.02 perms, and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E 84.

2.2 PIPE INSULATION SYSTEMS

Insulation materials shall conform to Table 1. Insulation thickness shall be as listed in Table 2 and meet or exceed the requirements of ASHRAE 90.1 - IP.

2.2.1 Aboveground Cold Pipeline (-30 to 60 deg. F)

Insulation for outdoor, indoor, exposed or concealed applications, shall be as follows:

a. Cellular Glass: ASTM C 552, Type II, and Type III. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

b. Flexible Elastomeric Cellular Insulation: ASTM C 534, Grade 1, Type I or II. Type II shall have vapor retarder/vapor barrier skin on one or both sides of the insulation. Insulation with pre-applied adhesive shall not be used.

c. Phenolic Insulation: ASTM C 1126, Type III. Phenolic insulations shall comply with ASTM C 795 and with the ASTM C 665 paragraph Corrosiveness. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

d. Polyisocyanurate Insulation: ASTM C 591, type I. Supply the insulation with manufacturer's recommended factory-applied vapor retarder/vapor barrier. Insulation with pre-applied adhesive shall not be used.

2.2.2 Aboveground Hot Pipeline (Above 60 deg. F)

Insulation for outdoor, indoor, exposed or concealed applications shall meet the following requirements. Supply the insulation with manufacturer's

recommended factory-applied jacket/vapor barrier.

a. Mineral Fiber: ASTM C 547, Types I, II or III, supply the insulation with manufacturer's recommended factory-applied jacket.

b. Calcium Silicate: ASTM C 533, Type I indoor only, or outdoors above 250 degrees F pipe temperature. Supply insulation with the manufacturer's recommended factory-applied jacket/vapor barrier.

c. Cellular Glass: ASTM C 552, Type II and Type III. Supply the insulation with manufacturer's recommended factory-applied jacket.

d. Flexible Elastomeric Cellular Insulation: ASTM C 534, Grade 1, Type I or II to 200 degrees F service.

e. Phenolic Insulation: ASTM C 1126 Type III to 250 degrees F service shall comply with ASTM C 795. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

f. Perlite Insulation: ASTM C 610

g. Polyisocyanurate Insulation: ASTM C 591, Type 1, to 300 degrees F service. Supply the insulation with manufacturer's recommended factory applied jacket/vapor barrier.

2.2.3 Below-ground Pipeline Insulation

For below-ground pipeline insulation the following requirements shall be met.

2.2.3.1 Cellular Glass

ASTM C 552, type II.

2.2.3.2 Polyisocyanurate

ASTM C 591, Type 1, to 300 degrees F.

2.3 DUCT INSULATION SYSTEMS

2.3.1 Duct Insulation

Provide factory-applied cellular glass polyisocyanurate or phenolic foam. I nsulation with insulation manufacturer's standard reinforced fire-retardant vapor barrier, with identification of installed thermal resistance (R) value and out-of-package R value.

2.3.1.1 Rigid Insulation

Rigid mineral fiber in accordance with ASTM C 612, Class 2 (maximum surface temperature 400 degrees F), 3 pcf average, 1-1/2 inch thick, Type IA, IB, II, III, and IV. ASHRAE 90.1 - IP.

2.3.1.2 Blanket Insulation

Blanket flexible mineral fiber insulation conforming to ASTM C 553, Type 1, Class B-3, 3/4 pcf nominal, 2.0 inches thick or Type II up to 250 degrees F. Also ASTM C 1290 Type III may be used.

2.3.2 Duct Insulation Jackets

2.3.2.1 All-Purpose Jacket

Provide insulation with insulation manufacturer's standard reinforced fire-retardant jacket with or without integral vapor barrier as required by the service. In exposed locations, provide jacket with a white surface suitable for field painting.

2.3.2.2 Metal Jackets

a. Aluminum Jackets: ASTM B 209, Temper H14, minimum thickness of 27 gauge (0.016 inch), with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide smooth surface jackets for jacket outside dimension 8 inches and larger. Provide corrugated surface jackets for jacket outside dimension 8 inches and larger. Provide stainless steel bands, minimum width of 1/2 inch.

b. Stainless Steel Jackets: ASTM A 167 or ASTM A 240/A 240M; Type 304, minimum thickness of 33 gauge (0.010 inch), smooth surface with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide stainless steel bands, minimum width of 1/2 inch.

2.3.3 Weatherproof Duct Insulation

Provide ASTM C 591 Type I, polyurethane or polyisocyanate board insulation, minimum density of 1.7 pcf and weatherproofing as specified in manufacturer's instruction.

2.4 EQUIPMENT INSULATION SYSTEMS

Insulate equipment and accessories as specified in Tables 4 and 5. In outside locations, provide insulation 1/2 inch thicker than specified. Increase the specified insulation thickness for equipment where necessary to equal the thickness of angles or other structural members to make a smooth, exterior surface.

PART 3 EXECUTION

3.1 APPLICATION - GENERAL

Insulation shall only be applied to unheated and uncooled piping and equipment. Flexible elastomeric cellular insulation shall not be compressed at joists, studs, columns, ducts, hangers, etc. The insulation shall not pull apart after a one hour period; any insulation found to pull apart after one hour, shall be replaced.

3.1.1 Installation

Except as otherwise specified, material shall be installed in accordance with the manufacturer's written instructions. Insulation materials shall not be applied until tests and heat tracing specified in other sections of this specification are completed. Material such as rust, scale, dirt and moisture shall be removed from surfaces to receive insulation. Insulation shall be kept clean and dry. Insulation shall not be removed from its shipping containers until the day it is ready to use and shall be returned to like containers or equally protected from dirt and moisture at the end

of each workday. Insulation that becomes dirty shall be thoroughly cleaned prior to use. If insulation becomes wet or if cleaning does not restore the surfaces to like new condition, the insulation will be rejected, and shall be immediately removed from the jobsite. Joints shall be staggered on multi layer insulation. Mineral fiber thermal insulating cement shall be mixed with demineralized water when used on stainless steel surfaces. Insulation, jacketing and accessories shall be installed in accordance with MICA Insulation Stds plates except where modified herein or on the drawings.

3.1.2 Firestopping

Where pipes and ducts pass through fire walls, fire partitions, above grade floors, and fire rated chase walls, the penetration shall be sealed with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING.

3.1.3 Painting and Finishing

Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.1.4 Installation of Flexible Elastomeric Cellular Insulation

Flexible elastomeric cellular insulation shall be installed with seams and joints sealed with rubberized contact adhesive. Flexible elastomeric cellular insulation shall not be used on surfaces greater than 200 degrees F. Seams shall be staggered when applying multiple layers of insulation. Insulation exposed to weather and not shown to have jacketing shall be protected with two coats of UV resistant finish or PVC or metal jacketing as recommended by the manufacturer after the adhesive is dry and cured. A brush coating of adhesive shall be applied to both butt ends to be joined and to both slit surfaces to be sealed. The adhesive shall be allowed to set until dry to touch but tacky under slight pressure before joining the surfaces. Insulation seals at seams and joints shall not be capable of being pulled apart one hour after application. Insulation that can be pulled apart one hour after installation shall be replaced.

3.1.5 Welding

No welding shall be done on piping, duct or equipment without written approval of the Contracting Officer. The capacitor discharge welding process may be used for securing metal fasteners to duct.

3.1.6 Pipes/Ducts/Equipment which Require Insulation

Insulation is required on all pipes, ducts, or equipment, except for omitted items, as specified.

3.2 PIPE INSULATION SYSTEMS INSTALLATION

Install pipe insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions.

3.2.1 Pipe Insulation

3.2.1.1 General

Pipe insulation shall be installed on aboveground hot and cold pipeline systems as specified below to form a continuous thermal retarder/barrier, including straight runs, fittings and appurtenances unless specified

otherwise. Installation shall be with full length units of insulation and using a single cut piece to complete a run. Cut pieces or scraps abutting each other shall not be used. Pipe insulation shall be omitted on the following:

a. Pipe used solely for fire protection.

b. Chromium plated pipe to plumbing fixtures. However, fixtures for use by the physically handicapped shall have the hot water supply and drain, including the trap, insulated where exposed.

c. Sanitary drain lines.

d. Air chambers.

e. Adjacent insulation.

f. ASME stamps.

g. Access plates of fan housings.

h. Cleanouts or handholes.

3.2.1.2 Pipes Passing Through Walls, Roofs, and Floors

a. Pipe insulation shall be continuous through the sleeve.

b. An aluminum jacket or vapor barrier/weatherproofing - self adhesive jacket (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, greater than 3 ply standard grade, silver, white, black and embossed with factory applied moisture retarder shall be provided over the insulation wherever penetrations require sealing.

c. Where pipes penetrate interior walls, the aluminum jacket or vapor barrier/weatherproofing - self adhesive jacket (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, greater than 3 plys standard grade, silver, white, black and embossed shall extend 2 inches beyond either side of the wall and shall be secured on each end with a band.

d. Where penetrating floors, the aluminum jacket shall extend from a point below the backup material to a point 10 inches above the floor with one band at the floor and one not more than 1 inch from the end of the aluminum jacket.

e. Where penetrating waterproofed floors, the aluminum jacket shall extend from below the backup material to a point 2 inches above the flashing with a band 1 inch from the end of the aluminum jacket.

f. Where penetrating exterior walls, the aluminum jacket required for pipe exposed to weather shall continue through the sleeve to a point 2 inches beyond the interior surface of the wall.

g. Where penetrating roofs, pipe shall be insulated as required for interior service to a point flush with the top of the flashing and sealed with vapor retarder coating. The insulation for exterior application shall butt tightly to the top of flashing and interior

insulation. The exterior aluminum jacket shall extend 2 inches down beyond the end of the insulation to form a counter flashing. The flashing and counter flashing shall be sealed underneath with caulking.

h. For hot water pipes supplying lavatories or other similar heated service that requires insulation, the insulation shall be terminated on the backside of the finished wall. The insulation termination shall be protected with two coats of vapor barrier coating with a minimum total thickness of 1/16 inch applied with glass tape embedded between coats (if applicable). The coating shall extend out onto the insulation 2 inches and shall seal the end of the insulation. Glass tape seams shall overlap 1 inch. The annular space between the pipe and wall penetration shall be caulked with approved fire stop material. The pipe and wall penetration shall be covered with a properly sized (well fitting) escutcheon plate. The escutcheon plate shall overlap the wall penetration at least 3/8 inches.

i. For domestic cold water pipes supplying lavatories or other similar cooling service that requires insulation, the insulation shall be terminated on the finished side of the wall (i.e., insulation must cover the pipe throughout the wall penetration). The insulation shall be protected with two coats of vapor barrier coating with a minimum total thickness of 1/16 inch. The coating shall extend out onto the insulation 2 inches and shall seal the end of the insulation. The annular space between the outer surface of the pipe insulation and the wall penetration shall be caulked with an approved fire stop material having vapor retarder properties. The pipe and wall penetration shall be covered with a properly sized (well fitting) escutcheon plate. The escutcheon plate shall overlap the wall penetration by at least 3/8 inches.

3.2.1.3 Pipes Passing Through Hangers

a. Insulation, whether hot or cold application, shall be continuous through hangers. All horizontal pipes 2 inches and smaller shall be supported on hangers with the addition of a Type 40 protection shield to protect the insulation in accordance with MSS SP-69. Whenever insulation shows signs of being compressed, or when the insulation or jacket shows visible signs of distortion at or near the support shield, insulation inserts as specified below for piping larger than 2 inches shall be installed, or factory insulated hangers (designed with a load bearing core) can be used.

b. Horizontal pipes larger than 2 inches at 60 degrees F and above shall be supported on hangers in accordance with MSS SP-69, and Section 22 00 00 PLUMBING, GENERAL PURPOSE .

c. Horizontal pipes larger than 2 inches and below 60 degrees F shall be supported on hangers with the addition of a Type 40 protection shield in accordance with MSS SP-69. An insulation insert of cellular glass, calcium silicate (or perlite above 80 degrees F), or the necessary strength polyisocyanurate shall be installed above each shield. The insert shall cover not less than the bottom 180-degree arc of the pipe. Inserts shall be the same thickness as the insulation, and shall extend 2 inches on each end beyond the protection shield. When insulation inserts are required per the above, and the insulation thickness is less than

1 inch, wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the weight of the pipe from crushing the insulation, as an option to installing insulation inserts. The insulation jacket shall be continuous over the wooden dowel, wooden block, or insulation insert.

d. Vertical pipes shall be supported with either Type 8 or Type 42 riser clamps with the addition of two Type 40 protection shields in accordance with MSS SP-69 covering the 360-degree arc of the insulation. An insulation insert of cellular glass or calcium silicate shall be installed between each shield and the pipe. The insert shall cover the 360-degree arc of the pipe. Inserts shall be the same thickness as the insulation, and shall extend 2 inches on each end beyond the protection shield. When insulation inserts are required per the above, and the insulation thickness is less than 1 inch, wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the hanger from crushing the insulation, as an option instead of installing insulation inserts. The insulation jacket shall be continuous over the wooden dowel, wooden block, or insulation insert. The vertical weight of the pipe shall be supported with hangers located in a horizontal section of the pipe. When the pipe riser is longer than 30 feet, the weight of the pipe shall be additionally supported with hangers in the vertical run of the pipe that are directly clamped to the pipe, penetrating the pipe insulation. These hangers shall be insulated and the insulation jacket sealed as indicated herein for anchors in a similar service.

e. Inserts shall be covered with a jacket material of the same appearance and quality as the adjoining pipe insulation jacket, shall overlap the adjoining pipe jacket 1-1/2 inches, and shall be sealed as required for the pipe jacket. The jacket material used to cover inserts in flexible elastomeric cellular insulation shall conform to ASTM C 1136, Type 1, and is allowed to be of a different material than the adjoining insulation material.

3.2.1.4 Flexible Elastomeric Cellular Pipe Insulation

Flexible elastomeric cellular pipe insulation shall be tubular form for pipe sizes 6 inches and less. Grade 1, Type II sheet insulation used on pipes larger than 6 inches shall not be stretched around the pipe. On pipes larger than 12 inches, the insulation shall be adhered directly to the pipe on the lower 1/3 of the pipe. Seams shall be staggered when applying multiple layers of insulation. Sweat fittings shall be insulated with miter-cut pieces the same size as on adjacent piping. Screwed fittings shall be insulated with sleeved fitting covers fabricated from miter-cut pieces and shall be overlapped and sealed to the adjacent pipe insulation.

3.2.1.5 Pipes in high abuse areas.

In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, welded PVC jackets shall be utilized. Pipe insulation to the 6 foot level shall be protected.

3.2.1.6 Pipe Insulation Material and Thickness

TABLE 1
Insulation Material For Piping (°F)

Service	Material	Spec.	Type	Class	Vapor Retarder/ Vapor Barrier Required
Chilled Water (Supply & Return, Dual Temperature Piping, 40°F nominal)	Cellular Glass	ASTM C 552	II	2	No
	Flex Elast Cell'r	ASTM C 534	I		No
	Faced Phenol Foam	ASTM C 1126	III		Yes
	Polyisocianurate	ASTM C 591	I		Yes
Heating Hot Water Supply & Return, Heated Oil (Max 250°F)	Mineral Fiber	ASTM C 547	I	1	No
	Calcium Silicate	ASTM C 533	I		No
	Cellular Glass	ASTM C 552	II	2	No
	Faced Phenol Foam	ASTM C 1126	III		Yes
	Perlite	ASTM C 610			No
	Polyisocianurate	ASTM C 591	I		No
Cold Domestic Water Piping, Makeup Water & Drinking Fount Drain Piping	Polyisocianurate	ASTM C 591	I		Yes
	Cellular Glass	ASTM C 552	II	2	No
	Flex Elast Cell'r	ASTM C 534	I		No
	Faced Phenol Foam	ASTM C 1126	III		Yes
Hot Domestic Water Supply & Recirculating Piping (Max. 200°F)	Mineral Fiber	ASTM C 547	I	1	No
	Cellular Glass	ASTM C 552	II	2	No
	Flex Elast Cell'r	ASTM C 534	I		No
	Faced Phenol Foam	ASTM C 1126	III		Yes
	Polyisocianurate	ASTM C 591	I		No
Refrigerant Suction Piping (35°F nominal)	Flex Elast Cell'r	ASTM C 534	I		No
	Cellular Glass	ASTM C 552	II	1	Yes
	Faced Phenol Foam	ASTM C 1126	III		Yes
	Polyisocianurate	ASTM C 591	I		Yes
Exposed Lav'ry Drains, Expo'd Domestic Water Piping & Drains to Areas for Handicap Personnel	Flex Elast Cell'r	ASTM C 534	I		No
Horizontal Roof Drain Leaders (Including Underside of Roof Drain Fittings)	Polyisocianurate	ASTM C 591	I		Yes
	Flex Elast Cell'r	ASTM C 534	I		No
	Faced Phenol Foam	ASTM C 1126	III		Yes
	Cellular Glass	ASTM C 552	III		Yes
A/C condensate Drain Located	Polyisocianurate	ASTM C 591	I		Yes
	Cellular Glass	ASTM C 552	II	2	No

TABLE 1
Insulation Material For Piping (°F)

Service	Material	Spec.	Type	Class	Vapor Retarder/ Vapor Barrier Required
Inside Bldg.	Flex Elast Cell'r	ASTM C 534	I		No
	Faced Phenol Foam	ASTM C 1126	II		Yes

TABLE 2
Piping Insulation Thickness (inch and °F)

		Tube And Pipe Size (Inches)				
Service	Material	<1	1- <1.5	1.5- <4	4- <8	>or = to 8
Chilled Water (Supply & Return, (40°F Nominal)	Cellular Glass	1.5	2	2	2.5	3
	Faced Phenol Foam	1	1	1	1.5	1.5
	Polyisocianurate	1	1	1	1	1
	Mineral Fiber with Wicking Material	1	1.5	1.5	2	2
	Cellular Glass	1.5	1.5	1.5	1.5	2
	Flex Elas Cell'r	1	1	1	N/A	N/A
	Faced Phenol Foam	1	1	1	1	1.5
Heating Hot Water Supply & Return, (Max. 250°F)	Mineral Fiber	1.5	1.5	2	2	2
	Calcium Silicate	2.5	2.5	3	3	3
	Cellular Glass	2	2 5	3	3	3
	Perlite	2.5	2.5	3	3	3
	Polyisocianurate	1	1	1.5	1.5	1.5
Cold Domestic Water Piping, Makeup Water, & Drinking Fountain Drain Piping	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flex Elas Cell'r	1	1	1	N/A	N/A
	Faced Phenol Foam	1	1	1	1	1
	Polyisocianurate	1	1	1	1	1
Hot Domestic Water Supply and Recirculating Piping (Max 200°F)	Mineral Fiber	1	1	1	1.5	1.5
	Cellular Glass	1.5	1.5	1.5	2	2
	Flex Elas Cell'r	1	1	1	N/A	N/A
	Polyisocianurate	1	1	1	1	1.5
Refrigerant Suction Piping (35°F nominal)	Flex Elas Cell'r	0.5	0.5	1	N/A	N/A
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Faced Phenol Foam	1	1	1	1	1
	Polyisocianurate	1	1	1	1	1
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains	Flex Elas Cell'r	0.5	0.5	0.5	0.5	0.5

TABLE 2
Piping Insulation Thickness (inch and °F)

Service	Material	Tube And Pipe Size (Inches) <1	1- <1.5	1.5- <4	4- <8	>or = to 8
to Areas for Handicap Personnel						
Horizontal Roof Drain Leaders (including Underside of Roof Drain Fitting)	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flex Elas Cell'r	1	1	1	1	1
	Faced Phenol Foam	1	1	1	1	1
	Polyisocianurate	1	1	1	1	1
A/C condensate Drain Located Inside Bldg.	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flex Elas Cell'r	1	1	1	N/A	N/A
	Faced Phenol Foam	1	1	1	1	1

3.2.2 Aboveground Cold Pipelines

The following cold pipelines for minus 30 to plus 60 degrees F, shall be insulated per Table 2 except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted. This includes but is not limited to the following:

a. Domestic cold water.

b. Make-up water.

c. Horizontal and vertical portions of interior roof drains.

d. Refrigerant suction lines.

e. Chilled water.

f. Air conditioner condensate drains.

g. Exposed lavatory drains and domestic water lines serving plumbing fixtures for handicap persons.

3.2.2.1 Insulation Material and Thickness

Insulation thickness for cold pipelines shall be determined using Table 2.

3.2.2.2 Jacket for Mineral Fiber, Cellular Glass, Phenolic Foam, and Polyisocyanurate Foam Insulated Pipe

Insulation shall be covered with a factory applied vapor retarder jacket/vapor barrier or field applied seal welded PVC jacket or greater than 3 ply laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, standard grade, sliver, white, black and embossed. Insulation inside the building, to be protected with an aluminum jacket or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2

mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, Embossed Silver, White & Black, shall have the insulation and vapor retarder jacket installed as specified herein. The aluminum jacket or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, embossed silver, White & Black, shall be installed as specified for piping exposed to weather, except sealing of the laps of the aluminum jacket is not required. In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, aluminum jackets or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, embossed silver, white & black, shall be provided for pipe insulation to the 6 ft level.

3.2.2.3 Installing Insulation for Straight Runs Hot and Cold Pipe

a. Insulation shall be applied to the pipe with joints tightly butted. All butted joints and ends shall be sealed with joint sealant and sealed with a vapor retarder coating, greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or PVDC adhesive tape.

b. Longitudinal laps of the jacket material shall overlap not less than 1-1/2 inches. Butt strips 3 inches wide shall be provided for circumferential joints.

c. Laps and butt strips shall be secured with adhesive and stapled on 4 inch centers if not factory self-sealing. If staples are used, they shall be sealed per item "e." below. Note that staples are not required with cellular glass systems.

d. Factory self-sealing lap systems may be used when the ambient temperature is between 40 and 120 degrees F during installation. The lap system shall be installed in accordance with manufacturer's recommendations. Stapler shall be used only if specifically recommended by the manufacturer. Where gaps occur, the section shall be replaced or the gap repaired by applying adhesive under the lap and then stapling.

e. All Staples, including those used to repair factory self-seal lap systems, shall be coated with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape. All seams, except those on factory self-seal systems shall be coated with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

f. Breaks and punctures in the jacket material shall be patched by wrapping a strip of jacket material around the pipe and securing it with adhesive, stapling, and coating with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape. The patch shall extend not less than 1-1/2 inches past the break.

g. At penetrations such as thermometers, the voids in the insulation shall be filled and sealed with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or greater than 3 ply laminate jacket -

less than 0.0000 perm adhesive tape.

h. Installation of flexible elastomeric cellular pipe insulation shall be by slitting the tubular sections and applying them onto the piping or tubing. Alternately, whenever possible slide un-slit sections over the open ends of piping or tubing. All seams and butt joints shall be secured facing up and sealed with adhesive. When using self seal products only the butt joints shall be secured with adhesive. Insulation shall be pushed on the pipe, never pulled. Stretching of insulation resulting in open seams and joints is not permitted. All edges shall be clean cut. Rough or jagged edges of the insulation shall not be permitted. Proper tools such as sharp knives shall be used. Grade 1, Type II sheet insulation when used on pipe larger than 6 inches shall not be stretched around the pipe. On pipes larger than 12 inches, adhere sheet insulation directly to the pipe on the lower 1/3 of the pipe.

3.2.2.4 Insulation for Fittings and Accessories

a. Pipe insulation shall be tightly butted to the insulation of the fittings and accessories. The butted joints and ends shall be sealed with joint sealant and sealed with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

b. Precut or preformed insulation shall be placed around all fittings and accessories and shall conform to MICA plates except as modified herein: 5 for anchors; 10, 11, and 13 for fittings; 14 for valves; and 17 for flanges and unions. Insulation shall be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity. Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Insulation of the same thickness and conductivity as the adjoining pipe insulation shall be used. If nesting size insulation is used, the insulation shall be overlapped 2 inches or one pipe diameter. Elbows insulated using segments shall conform to MICA Tables 12.20 "Mitered Insulation Elbow'.

c. Upon completion of insulation installation on flanges, unions, valves, anchors, fittings and accessories, terminations, seams, joints and insulation not protected by factory vapor retarder jackets or PVC fitting covers shall be protected with PVDC or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or two coats of vapor retarder coating with a minimum total thickness of 1/16 inch, applied with glass tape embedded between coats. Tape seams shall overlap 1 inch. The coating shall extend out onto the adjoining pipe insulation 2 inches. Fabricated insulation with a factory vapor retarder jacket shall be protected with either greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape, standard grade, silver, white, black and embossed or PVDC adhesive tape or two coats of vapor retarder coating with a minimum thickness of 1/16 inch and with a 2 inch wide glass tape embedded between coats. Where fitting insulation butts to pipe insulation, the joints shall be sealed with a vapor retarder coating and a 4 inch wide ASJ tape which matches the jacket of the pipe insulation.

d. Anchors attached directly to the pipe shall be insulated for a sufficient distance to prevent condensation but not less than 6 inches from the insulation surface.

e. Insulation shall be marked showing the location of unions, strainers, and check valves.

3.2.2.5 Optional PVC Fitting Covers

At the option of the Contractor, premolded, one or two piece PVC fitting covers may be used in lieu of the vapor retarder and embedded glass tape. Factory precut or premolded insulation segments shall be used under the fitting covers for elbows. Insulation segments shall be the same insulation as the pipe insulation including same density, thickness, and thermal conductivity. The covers shall be secured by PVC vapor retarder tape, adhesive, seal welding or with tacks made for securing PVC covers. Seams in the cover, and tacks and laps to adjoining pipe insulation jacket, shall be sealed with vapor retarder tape to ensure that the assembly has a continuous vapor seal.

3.2.3 Aboveground Hot Pipelines

3.2.3.1 General Requirements

All hot pipe lines above 60 degrees F, except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted, shall be insulated per Table 2. This includes but is not limited to the following:

a. Domestic hot water supply & re-circulating system.

b. Condensate & compressed air discharge.

c. Hot water heating.

Insulation shall be covered, in accordance with manufacturer's recommendations, with a factory applied Type I jacket or field applied aluminum where required or seal welded PVC.

3.2.3.2 Insulation for Fittings and Accessories

a. General. Pipe insulation shall be tightly butted to the insulation of the fittings and accessories. The butted joints and ends shall be sealed with joint sealant. Insulation shall be marked showing the location of unions, strainers, check valves and other components that would otherwise be hidden from view by the insulation.

b. Precut or Preformed. Precut or preformed insulation shall be placed around all fittings and accessories. Insulation shall be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity.

c. Rigid Preformed. Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Insulation of the same thickness and conductivity as the adjoining pipe insulation shall be used. If nesting size insulation is used, the insulation shall be overlapped 2 inches or one pipe diameter. Elbows insulated using segments shall conform to MICA Tables 12.20 "Mitered Insulation Elbow".

3.2.4 Piping Exposed to Weather

Piping exposed to weather shall be insulated and jacketed as specified for the applicable service inside the building. After this procedure, a laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability (greater than 3 ply, standard grade, silver, white, black and embossed aluminum jacket or PVC jacket shall be applied. PVC jacketing requires no factory-applied jacket beneath it, however an all service jacket shall be applied if factory applied jacketing is not furnished. Flexible elastomeric cellular insulation exposed to weather shall be treated in accordance with paragraph INSTALLATION OF FLEXIBLE ELASTOMERIC CELLULAR INSULATION in PART 3.

3.2.4.1 Aluminum Jacket

The jacket for hot piping may be factory applied. The jacket shall overlap not less than 2 inches at longitudinal and circumferential joints and shall be secured with bands at not more than 12 inch centers. Longitudinal joints shall be overlapped down to shed water and located at 4 or 8 o'clock positions. Joints on piping 60 degrees F and below shall be sealed with caulking while overlapping to prevent moisture penetration. Where jacketing on piping 60 degrees F and below abuts an un-insulated surface, joints shall be caulked to prevent moisture penetration. Joints on piping above 60 degrees F shall be sealed with a moisture retarder.

3.2.4.2 Insulation for Fittings

Flanges, unions, valves, fittings, and accessories shall be insulated and finished as specified for the applicable service. Two coats of breather emulsion type weatherproof mastic (impermeable to water, permeable to air) recommended by the insulation manufacturer shall be applied with glass tape embedded between coats. Tape overlaps shall be not less than 1 inch and the adjoining aluminum jacket not less than 2 inches. Factory preformed aluminum jackets may be used in lieu of the above. Molded PVC fitting covers shall be provided when PVC jackets are used for straight runs of pipe. PVC fitting covers shall have adhesive welded joints and shall be weatherproof laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed, and UV resistant.

3.2.4.3 PVC Jacket

PVC jacket shall be ultraviolet resistant and adhesive welded weather tight with manufacturer's recommended adhesive. Installation shall include provision for thermal expansion.

3.3 DUCT INSULATION SYSTEMS INSTALLATION

Install duct insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions.

Corner angles shall be installed on external corners of insulation on ductwork in exposed finished spaces before covering with jacket. Air conditioned spaces shall be defined as those spaces directly supplied with cooled conditioned air (or provided with a cooling device such as a fan-coil unit) and heated conditioned air (or provided with a heating

device such as a unit heater, radiator or convector).

3.3.1 Duct Insulation Thickness

Duct insulation thickness shall be in accordance with Table 4.

Table 4 - Minimum Duct Insulation (inches)

Cold Air Ducts	2.0
Relief Ducts	1.5
Fresh Air Intake Ducts	1.5
Warm Air Ducts	2.0
Relief Ducts	1.5
Fresh Air Intake Ducts	1.5

3.3.2 Insulation and Vapor Retarder/Vapor Barrier for Cold Air Duct

Insulation and vapor retarder/vapor barrier shall be provided for the following cold air ducts and associated equipment.

a. Supply ducts.

b. Return air ducts.

c. Relief ducts.

d. Flexible run-outs (field-insulated).

e. Plenums.

f. Duct-mounted coil casings.

g. Coil headers and return bends.

h. Coil casings.

i. Fresh air intake ducts.

j. Filter boxes.

k. Mixing boxes (field-insulated).

l. Supply fans (field-insulated).

m. Site-erected air conditioner casings.

n. Ducts exposed to weather.

o. Combustion air intake ducts.

Insulation for rectangular ducts shall be flexible type where concealed, minimum density 3/4 pcf, and rigid type where exposed, minimum density 3 pcf. Insulation for both concealed or exposed round/oval ducts shall be flexible type, minimum density 3/4 pcf or a semi rigid board, minimum density 3 pcf, formed or fabricated to a tight fit, edges beveled and joints tightly butted and staggered. Insulation for all exposed ducts shall be provided

with either a white, paint-able, factory-applied Type I jacket or a field applied vapor retarder/vapor barrier jacket coating finish as specified, the total field applied dry film thickness shall be approximately 1/16 inch. Insulation on all concealed duct shall be provided with a factory-applied Type I or II vapor retarder/vapor barrier jacket. Duct insulation shall be continuous through sleeves and prepared openings except firewall penetrations. Duct insulation terminating at fire dampers, shall be continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air and which may be prone to condensate formation. Duct insulation and vapor retarder/vapor barrier shall cover the collar, neck, and any un-insulated surfaces of diffusers, registers and grills. Vapor retarder/vapor barrier materials shall be applied to form a complete unbroken vapor seal over the insulation. Sheet Metal Duct shall be sealed in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

3.3.2.1 Installation on Concealed Duct

a. For rectangular, oval or round ducts, flexible insulation shall be attached by applying adhesive around the entire perimeter of the duct in 6 inch wide strips on 12 inch centers.

b. For rectangular and oval ducts, 24 inches and larger insulation shall be additionally secured to bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on 16 inch centers and not more than 16 inches from duct corners.

c. For rectangular, oval and round ducts, mechanical fasteners shall be provided on sides of duct risers for all duct sizes. Fasteners shall be spaced on 16 inch centers and not more than 16 inches from duct corners.

d. Insulation shall be impaled on the mechanical fasteners (self stick pins) where used and shall be pressed thoroughly into the adhesive. Care shall be taken to ensure vapor retarder/vapor barrier jacket joints overlap 2 inches. The insulation shall not be compressed to a thickness less than that specified. Insulation shall be carried over standing seams and trapeze-type duct hangers.

e. Where mechanical fasteners are used, self-locking washers shall be installed and the pin trimmed and bent over.

f. Jacket overlaps shall be secured with staples and tape as necessary to ensure a secure seal. Staples, tape and seams shall be coated with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.

g. Breaks in the jacket material shall be covered with patches of the same material as the vapor retarder jacket. The patches shall extend not less than 2 inches beyond the break or penetration in all directions and shall be secured with tape and staples. Staples and tape joints shall be sealed with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.

h. At jacket penetrations such as hangers, thermometers, and damper operating rods, voids in the insulation shall be filled and the

penetration sealed with a brush coat of vapor retarder coating or PVDC adhesive tape greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.

i. Insulation terminations and pin punctures shall be sealed and flashed with a reinforced vapor retarder coating finish or tape with a brush coat of vapor retarder coating.. The coating shall overlap the adjoining insulation and un-insulated surface 2 inches. Pin puncture coatings shall extend 2 inches from the puncture in all directions.

j. Where insulation standoff brackets occur, insulation shall be extended under the bracket and the jacket terminated at the bracket.

3.3.2.2 Installation on Exposed Duct Work

a. For rectangular ducts, rigid insulation shall be secured to the duct by mechanical fasteners on all four sides of the duct, spaced not more than 12 inches apart and not more than 3 inches from the edges of the insulation joints. A minimum of two rows of fasteners shall be provided for each side of duct 12 inches and larger. One row shall be provided for each side of duct less than 12 inches. Mechanical fasteners shall be as corrosion resistant as G60 coated galvanized steel, and shall indefinitely sustain a 50 lb tensile dead load test perpendicular to the duct wall.

b. Duct insulation shall be formed with minimum jacket seams. Each piece of rigid insulation shall be fastened to the duct using mechanical fasteners. When the height of projections is less than the insulation thickness, insulation shall be brought up to standing seams, reinforcing, and other vertical projections and shall not be carried over. Vapor retarder/barrier jacket shall be continuous across seams, reinforcing, and projections. When height of projections is greater than the insulation thickness, insulation and jacket shall be carried over. Apply insulation with joints tightly butted. Neatly bevel insulation around name plates and access plates and doors.

c. Insulation shall be impaled on the fasteners; self-locking washers shall be installed and the pin trimmed and bent over.

d. Joints in the insulation jacket shall be sealed with a 4 inch wide strip of tape. Tape seams shall be sealed with a brush coat of vapor retarder coating.

e. Breaks and ribs or standing seam penetrations in the jacket material shall be covered with a patch of the same material as the jacket. Patches shall extend not less than 2 inches beyond the break or penetration and shall be secured with tape and stapled. Staples and joints shall be sealed with a brush coat of vapor retarder coating.

f. At jacket penetrations such as hangers, thermometers, and damper operating rods, the voids in the insulation shall be filled and the penetrations sealed with a brush coat of vapor retarder coating.

g. Insulation terminations and pin punctures shall be sealed and

flashed with a reinforced vapor retarder coating finish. The coating shall overlap the adjoining insulation and un-insulated surface 2 inches. Pin puncture coatings shall extend 2 inches from the puncture in all directions.

h. Oval and round ducts, flexible type, shall be insulated with factory Type I jacket insulation with minimum density of 3/4 pcf, attached as per MICA standards.

3.3.3 Insulation for Warm Air Duct

Insulation and vapor barrier shall be provided for the following warm air ducts and associated equipment:.

a. Supply ducts.

b. Return air ducts

c. Relief air ducts

d. Flexible run-outs (field insulated)

e. Plenums

f. Duct-mounted coil casings

g. Coil-headers and return bends

h. Coil casings.

i. Fresh air intake ducts

j. Filter boxes

k. Mixing boxes

l. Supply fans

m. Site-erected air conditioner casings

n. Ducts exposed to weather

Insulation for rectangular ducts shall be flexible type where concealed, and rigid type where exposed. Insulation on exposed ducts shall be provided with a white, paint-able, factory-applied Type II jacket, or finished with adhesive finish. Flexible type insulation shall be used for round ducts, with a factory-applied Type II jacket. Insulation on concealed duct shall be provided with a factory-applied Type II jacket. Adhesive finish where indicated to be used shall be accomplished by applying two coats of adhesive with a layer of glass cloth embedded between the coats. The total dry film thickness shall be approximately 1/16 inch. Duct insulation shall be continuous through sleeves and prepared openings. Duct insulation shall terminate at fire dampers and flexible connections.

3.3.3.1 Installation on Concealed Duct

a. For rectangular, oval and round ducts, insulation shall be attached by applying adhesive around the entire perimeter of the duct in 6 inch wide strips on 12 inch centers.

b. For rectangular and oval ducts 24 inches and larger, insulation shall be secured to the bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on 18 inch centers and not more than 18 inches from duct corner.

c. For rectangular, oval and round ducts, mechanical fasteners shall be provided on sides of duct risers for all duct sizes. Fasteners shall be spaced on 18 inch centers and not more than 18 inches from duct corners.

d. The insulation shall be impaled on the mechanical fasteners where used. The insulation shall not be compressed to a thickness less than that specified. Insulation shall be carried over standing seams and trapeze-type hangers.

e. Self-locking washers shall be installed where mechanical fasteners are used and the pin trimmed and bent over.

f. Insulation jacket shall overlap not less than 2 inches at joints and the lap shall be secured and stapled on 4 inch centers.

3.3.3.2 Installation on Exposed Duct

a. For rectangular ducts, the rigid insulation shall be secured to the duct by the use of mechanical fasteners on all four sides of the duct, spaced not more than 16 inches apart and not more than 6 inches from the edges of the insulation joints. A minimum of two rows of fasteners shall be provided for each side of duct 12 inches and larger and a minimum of one row for each side of duct less than 12 inches.

b. Duct insulation with factory-applied jacket shall be formed with minimum jacket seams, and each piece of rigid insulation shall be fastened to the duct using mechanical fasteners. When the height of projection is less than the insulation thickness, insulation shall be brought up to standing seams, reinforcing, and other vertical projections and shall not be carried over the projection. Jacket shall be continuous across seams, reinforcing, and projections. Where the height of projections is greater than the insulation thickness, insulation and jacket shall be carried over the projection.

c. Insulation shall be impaled on the fasteners; self-locking washers shall be installed and pin trimmed and bent over.

d. Joints on jacketed insulation shall be sealed with a 4 inch wide strip of tape and brushed with vapor retarder coating.

e. Breaks and penetrations in the jacket material shall be covered with a patch of the same material as the jacket. Patches shall extend not less than 2 inches beyond the break or penetration and shall be secured with adhesive and stapled.

f. Insulation terminations and pin punctures shall be sealed with tape and brushed with vapor retarder coating.

g. Oval and round ducts, flexible type, shall be insulated with factory Type I jacket insulation, minimum density of 3/4 pcf

attached by staples spaced not more than 16 inches and not more than 6 inches from the degrees of joints. Joints shall be sealed in accordance with item "d." above.

3.3.4 Ducts Handling Air for Dual Purpose

For air handling ducts for dual purpose below and above 60 degrees F, ducts shall be insulated as specified for cold air duct.

3.3.5 Insulation for Evaporative Cooling Duct

Evaporative cooling supply duct located in spaces not evaporatively cooled, shall be insulated. Material and installation requirements shall be as specified for duct insulation for warm air duct.

3.3.6 Duct Test Holes

After duct systems have been tested, adjusted, and balanced, breaks in the insulation and jacket shall be repaired in accordance with the applicable section of this specification for the type of duct insulation to be repaired.

3.3.7 Duct Exposed to Weather

3.3.7.1 Installation

Ducts exposed to weather shall be insulated and finished as specified for the applicable service for exposed duct inside the building. After the above is accomplished, the insulation shall then be further finished as detailed in the following subparagraphs.

3.3.7.2 Round Duct

Laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - Less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply, heavy duty, white and natural) membrane shall be applied overlapping material by 3 inches no bands or caulking needed - see manufacturer's recommended installation instructions. Aluminum jacket with factory applied moisture retarder shall be applied with the joints lapped not less than 3 inches and secured with bands located at circumferential laps and at not more than 12 inch intervals throughout. Horizontal joints shall lap down to shed water and located at 4 or 8 o'clock position. Joints shall be sealed with caulking to prevent moisture penetration. Where jacketing abuts an un-insulated surface, joints shall be sealed with caulking.

3.3.7.3 Fittings

Fittings and other irregular shapes shall be finished as specified for rectangular ducts.

3.3.7.4 Rectangular Ducts

Two coats of weather barrier mastic reinforced with fabric or mesh for outdoor application shall be applied to the entire surface. Each coat of weatherproof mastic shall be 1/16 inch minimum thickness. The exterior shall be a metal jacketing applied for mechanical abuse and weather protection, and secured with screws.

3.4 EQUIPMENT INSULATION SYSTEMS INSTALLATION

Install equipment insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions.

3.4.1 General

Removable insulation sections shall be provided to cover parts of equipment that must be opened periodically for maintenance including vessel covers, fasteners, flanges and accessories. Equipment insulation shall be omitted on the following:

a. Hand-holes.

b. Boiler manholes.

c. Cleanouts.

d. ASME stamps.

e. Manufacturer's nameplates.

f. Duct Test/Balance Test Holes.

3.4.2 Insulation for Cold Equipment

Cold equipment below 60 degrees F: Insulation shall be furnished on equipment handling media below 60 degrees F including the following:

a. Pumps.

b. Refrigeration equipment parts that are not factory insulated.

c. Drip pans under chilled equipment.

d. Cold water storage tanks.

e. Water softeners.

f. Duct mounted coils.

g. Cold and chilled water pumps.

h. Pneumatic water tanks.

i. Roof drain bodies.

j. Air handling equipment parts that are not factory insulated.

k. Expansion and air separation tanks.

3.4.2.1 Insulation Type

Insulation shall be suitable for the temperature encountered. Material and thicknesses shall be as shown in Table 5:

Legend

RMF: Rigid Mineral Fiber
FMF: Flexible Mineral Fiber
CS: Calcium Silicate
PL: Perlite
CG: Cellular Glass
FC: Flexible Elastomeric Cellular
PF: Phenolic Foam
PC: Polyisocyanurate Foam

TABLE 5
Insulation Thickness for Cold Equipment (Inches and °F)

Equipment handling media at indicated temperature:	Material	Thickness
35 to 60 degrees F	CG	1.5 inches
	PF	1.5 inches
	FC	1.0 inches
	PC	1.0 inches
	PE	1.0 inches

3.4.2.2 Pump Insulation

a. Insulate pumps by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Joints between sides and between sides and bottom shall be joined by adhesive with lap strips for rigid mineral fiber and contact adhesive for flexible elastomeric cellular insulation. The box shall conform to the requirements of MICA Insulation Stds plate No. 49 when using flexible elastomeric cellular insulation. Joints between top cover and sides shall fit tightly forming a female shiplap joint on the side pieces and a male joint on the top cover, thus making the top cover removable.

b. Exposed insulation corners shall be protected with corner angles.

c. Upon completion of installation of the insulation, including removable sections, two coats of vapor retarder coating shall be applied with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 1/16 inch. A parting line shall be provided between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. Caulking shall be applied to parting line, between equipment and removable section insulation, and at all penetrations.

3.4.2.3 Other Equipment

a. Insulation shall be formed or fabricated to fit the equipment. To ensure a tight fit on round equipment, edges shall be beveled and joints shall be tightly butted and staggered.

b. Insulation shall be secured in place with bands or wires at intervals as recommended by the manufacturer but not more than 12 inch centers except flexible elastomeric cellular which shall be

adhered with contact adhesive. Insulation corners shall be protected under wires and bands with suitable corner angles.

c. Phenolic foam insulation shall be set in a coating of bedding compound and joints shall be sealed with bedding compound as recommended by the manufacturer. Cellular glass shall be installed in accordance with manufacturer's instructions. Joints and ends shall be sealed with joint sealant, and sealed with a vapor retarder coating.

d. Insulation on heads of heat exchangers shall be removable. Removable section joints shall be fabricated using a male-female shiplap type joint. The entire surface of the removable section shall be finished by applying two coats of vapor retarder coating with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 1/16 inch.

e. Exposed insulation corners shall be protected with corner angles.

f. Insulation on equipment with ribs shall be applied over 6 by 6 inches by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot welded to the equipment over the ribs. Insulation shall be secured to the fabric with J-hooks and 2 by 2 inches washers or shall be securely banded or wired in place on 12 inch centers.

3.4.2.4 Vapor Retarder/Vapor Barrier

Upon completion of installation of insulation, penetrations shall be caulked. Two coats of vapor retarder coating or vapor barrier jacket shall be applied over insulation, including removable sections, with a layer of open mesh synthetic fabric embedded between the coats. The total dry thickness of the finish shall be 1/16 inch. Caulking or vapor barrier tape shall be applied to parting line between equipment and removable section insulation.

3.4.3 Insulation for Hot Equipment

Insulation shall be furnished on equipment handling media above 60 degrees F including the following:

a. Heat exchangers.

b. Pumps handling media above 130 degrees F.

c. Air separation tanks.

d. Surge tanks.

e. Unjacketed boilers or parts of boilers.

f. Boiler flue gas connection from boiler to stack (if inside).

g. Induced draft fans.

3.4.3.1 Insulation

Insulation shall be suitable for the temperature encountered. Shell and tube-type heat exchangers shall be insulated for the temperature of the

shell medium.

Insulation thickness for hot equipment shall be determined using Table 6:

Legend

RMF: Rigid Mineral Fiber
FMF: Flexible Mineral Fiber
CS: Calcium Silicate
PL: Perlite
CG: Cellular Glass
FC: Flexible Elastomeric Cellular
PF: Phenolic Foam
PC: Polyisocyanurate Foam

TABLE 6
Insulation Thickness for Hot Equipment (Inches and °F)

Equipment handling steam or media to indicated pressure or temperature limit:	Material	Thickness
15 psig	RMF	2.0 inches
or	FMF	2.0 inches
250F	CS/PL	4.0 inches
	CG	3.0 inches
	PF	1.5 inches
	FC (<200F)	1.0 inches
	PC	1.0 inches

3.4.3.2 Insulation of Boiler Stack and Diesel Engine Exhaust Pipe

Inside mechanical Room, bevel insulation neatly around openings and provide sheet metal insulation stop strips around such openings. Apply a skim coat of hydraulic setting cement directly to insulation. Apply a flooding coat of adhesive over hydraulic setting cement, and while still wet, press a layer of glass cloth or tape into adhesive and seal laps and edges with adhesive. Coat glass cloth with adhesive. When dry, apply a finish coat of adhesive at can-consistency so that when dry no glass weave shall be observed. Provide metal jackets for stacks that are located above finished floor and spaces outside mechanical room. Apply metal jackets directly over insulation and secure with 3/4 inch wide metal bands spaced on 18 inch centers. Do not insulate name plates. Insulation type and thickness shall be in accordance with the following Table 7.

TABLE 7
Insulation and Thickness (Inches and °F) for
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees F)	Material	Outside Diameter (Inches) 1/4-1-1/4	1-1/2-3	3-1/2-5	6-10	11-36
Boiler Stack (Up to 400° F)	Mineral Fiber ASTM C 553 Class B-3,	NA	NA	3	3.5	4

TABLE 7
Insulation and Thickness (Inches and °F) for
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees F)	Material	Outside Diameter (Inches) 1/4-1-1/4	1-1/2-3	3-1/2-5	6-10	11-36
	ASTM C 547 Class 1, or ASTM C 612 Class 1					
	Calcium Silicate ASTM C 533, Type 1	NA	NA	3	3.5	4
	Cellular Glass ASTM C 552, Type II	1.5	1.5	1.5	2	2.5

3.4.3.3 Insulation of Pumps

Insulate pumps by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Bottom and sides shall be banded to form a rigid housing that does not rest on the pump. Joints between top cover and sides shall fit tightly. The top cover shall have a joint forming a female shiplap joint on the side pieces and a male joint on the top cover, making the top cover removable. Two coats of Class I adhesive shall be applied over insulation, including removable sections, with a layer of glass cloth embedded between the coats. A parting line shall be provided between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. The total dry thickness of the finish shall be 1/16 inch. Caulking shall be applied to parting line of the removable sections and penetrations.

3.4.3.4 Other Equipment

a. Insulation shall be formed or fabricated to fit the equipment. To ensure a tight fit on round equipment, edges shall be beveled and joints shall be tightly butted and staggered.

b. Insulation shall be secured in place with bands or wires at intervals as recommended by the manufacturer but not greater than 12 inch centers except flexible elastomeric cellular which shall be adhered. Insulation corners shall be protected under wires and bands with suitable corner angles.

c. On high vibration equipment, cellular glass insulation shall be set in a coating of bedding compound as recommended by the manufacturer, and joints shall be sealed with bedding compound. Mineral fiber joints shall be filled with finishing cement.

d. Insulation on heads of heat exchangers shall be removable. The removable section joint shall be fabricated using a male-female shiplap type joint. Entire surface of the removable section shall

be finished as specified.

e. Exposed insulation corners shall be protected with corner angles.

f. On equipment with ribs, such as boiler flue gas connection, draft fans, and fly ash or soot collectors, insulation shall be applied over 6 by 6 inch by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot welded to the equipment over the ribs. Insulation shall be secured to the fabric with J-hooks and 2 by 2 inch washers or shall be securely banded or wired in place on 12 inch (maximum) centers.

g. On equipment handling media above 600 degrees F, insulation shall be applied in two or more layers with joints staggered.

h. Upon completion of installation of insulation, penetrations shall be caulked. Two coats of adhesive shall be applied over insulation, including removable sections, with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 1/16 inch. Caulking shall be applied to parting line between equipment and removable section insulation.

3.4.4 Equipment Exposed to Weather

3.4.4.1 Installation

Equipment exposed to weather shall be insulated and finished in accordance with the requirements for ducts exposed to weather in paragraph DUCT INSULATION INSTALLATION.

3.4.4.2 Optional Panels

At the option of the Contractor, prefabricated metal insulation panels may be used in lieu of the insulation and finish previously specified. Thermal performance shall be equal to or better than that specified for field applied insulation. Panels shall be the standard catalog product of a manufacturer of metal insulation panels. Fastenings, flashing, and support system shall conform to published recommendations of the manufacturer for weatherproof installation and shall prevent moisture from entering the insulation. Panels shall be designed to accommodate thermal expansion and to support a 250 pound walking load without permanent deformation or permanent damage to the insulation. Exterior metal cover sheet shall be aluminum and exposed fastenings shall be stainless steel or aluminum.

-- End of Section --

SECTION 23 08 00.00 10

COMMISSIONING OF HVAC SYSTEMS
01/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATED AIR BALANCE COUNCIL (AABC)

ACG Commissioning Guideline	(2005) Commissioning Guideline

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB Commissioning Standard	(1999) Procedural Standards for Building Systems Commissioning

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA Commissioning Manual	(1994, 1st Ed) HVAC Systems Commissioning Manual

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED	(2002; R 2005) Leadership in Energy and Environmental Design(tm) Green Building Rating System for New Construction (LEED-NC)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Commissioning Plan; G, DO

Commissioning Plan prepared in accordance with Commissioning Standard, no later than 28 days after the approval of the Commissioning Specialist.

SD-03 Product Data

Pre-Functional Performance Test Checklists; G, DO

At least 28 days prior to the start of Pre-Functional Performance Test Checks. The schedule for the test checks shall be submitted at least 14 days prior to the start of Pre-Functional Performance

Test Checks.

Functional Performance Tests; G, DO

Test procedures at least 28 days prior to the start of Functional Performance Tests. The schedule for the tests at least 14 days prior to the start of Functional Performance Tests.

SD-06 Test Reports

Commissioning Report; G, DO

No later than 14 days after completion of Functional Performance Tests.

SD-07 Certificates

Commissioning Firm; G, DO

Certification of the proposed Commissioning Firm's qualifications by one of the following ACG, NEBB, or TABB to perform the duties specified herein and in other related Sections, no later than 21 days after the Notice to Proceed. The documentation shall include the date that the Certification was initially granted and the date that the current Certification expires. Any lapses in Certification of the proposed Commissioning Firm or disciplinary action taken by ACG, NEBB, or TABB against the proposed Commissioning Firm shall be described in detail.

Commissioning Specialist; G, DO

Certification of the proposed Commissioning Specialist's qualifications by one of the following ACG, NEBB, or TABB to perform the duties specified herein and in other related Sections, no later than 21 days after the Notice to Proceed. The documentation shall include the date that the Certification was initially granted and the date that the current Certification expires. Any lapses in Certification of the proposed Commissioning Specialist or disciplinary action taken by ACG, NEBB, or TABB against the proposed Commissioning Specialist shall be described in detail.

1.3 SIMILAR TERMS

In some instances, terminology differs between the Contract and the Commissioning Standard primarily because the intent of this Section is to use the industry standards specified, along with additional requirements listed herein to produce optimal results. The following table of similar terms is provided for clarification only. Contract requirements take precedent over the corresponding ACG, NEBB, or TABB requirements where differences exist.

SIMILAR TERMS

Contract Term	ACG	NEBB	TABB
Commissioning Standard	ACG Commissioning Guideline	Procedural Standards for Building Systems	SMACNA HVAC Commissioning Guideline

SIMILAR TERMS

Commissioning		Commissioning	
Commissioning Specialist	ACG Certified Commissioning Agent	NEBB Qualified Commissioning Administrator	TABB Certified Commissioning Supervisor

1.4 COMMISSIONING STANDARDS

Commissioning shall be performed in accordance with the requirements of the standard under which the Commissioning Firm's qualifications are approved, i.e., ACG Commissioning Guideline, NEBB Commissioning Standard, or SMACNA Commissioning Manual unless otherwise stated herein. All recommendations and suggested practices contained in the Commissioning Standard shall be considered mandatory. The Commissioning Standard shall be used for all aspects of Commissioning, including qualifications for the Commissioning Firm and Specialist and calibration of Commissioning instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the Commissioning Standard, the manufacturer's recommendations shall be adhered to. All quality assurance provisions of the Commissioning Standard such as performance guarantees shall be part of this contract. For systems or system components not covered in the Commissioning Standard, Commissioning procedures shall be developed by the Commissioning Specialist. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the Commissioning Standard used (ACG, NEBB, or TABB), the requirements and recommendations contained in these procedures and requirements shall be considered mandatory.

1.5 QUALIFICATIONS

1.5.1 Commissioning Firm

The Commissioning Firm shall be either a member of ACG or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor shall immediately notify the Contracting Officer and submit another Commissioning Firm for approval. Any firm that has been the subject of disciplinary action by the ACG, the NEBB, or the TABB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including Commissioning. All work specified in this Section and in other related Sections to be performed by the Commissioning Firm shall be considered invalid if the Commissioning Firm loses its certification prior to Contract completion and must be performed by an approved successor. These Commissioning services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The Commissioning Firm shall be a subcontractor of the prime Contractor and shall be financially and corporately independent of all other subContractors. The Commissioning Firm shall report to and be paid by the prime Contractor.

1.5.2 Commissioning Specialist

The Commissioning Specialist shall be an ACG Certified Commissioning Agent, a NEBB Qualified Commissioning Administrator, or a TABB Certified Commissioning Supervisor and shall be an employee of the approved Commissioning Firm. The certification shall be maintained for the entire

duration of duties specified herein. If, for any reason, the Commissioning Specialist loses subject certification during this period, the Contractor shall immediately notify the Contracting Officer and submit another Commissioning Specialist for approval. Any individual that has been the subject of disciplinary action by the ACG, the NEBB, or the TABB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including Commissioning. All work specified in this Section and in other related Sections performed by the Commissioning Specialist shall be considered invalid if the Commissioning Specialist loses his certification prior to Contract completion and must be performed by the approved successor.

1.6 COMMISSIONING SPECIALIST RESPONSIBILITIES

All Commissioning work specified herein and in related sections shall be performed under the direct guidance of the Commissioning Specialist. The Commissioning Specialist shall prepare the Commissioning Plan, which will be a comprehensive schedule and shall include all submittal requirements for procedures, notifications, reports and the Commissioning Report. After approval of the Commissioning Plan, the Contractor shall revise the Contract NAS schedule to reflect the schedule requirements in the Commissioning Plan.

1.7 SEQUENCING AND SCHEDULING

The work described in this Section shall begin only after all work required in related Sections has been successfully completed, and all test and inspection reports and operation and maintenance manuals required in these Sections have been submitted and approved. Pre-Functional Performance Test Checklists shall be performed at appropriate times during the construction phase of the Contract.

1.8 ENERGY

Formal LEED certification is not required; however, the Contractor is required to provide documentation that meets the LEED Energy & Atmosphere (EA) Prerequisite 1, Fundamental Commissioning. For New Construction and Major Revisions the Contractor shall also provide documentation that meets EA Credit 3; Enhanced Commissioning. The Contractor shall provide documentation for as many LEED credits as possible to support LEED Silver certification of the project.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 COMMISSIONING TEAM AND TEST FORMS AND CHECKLISTS

The Contractor shall designate Contractor team members to participate in the Pre- Functional Performance Test Checklists and the Functional Performance Tests specified herein. In addition, the Government team members will be include a representative of the Contracting Officer, the Design Agent's Representative, and the Using Agency's Representative. The team members shall be as follows:

Designation	Function
A	Contractor's Commissioning Specialist
M	Contractor's Mechanical Representative

E Contractor's Electrical Representative
T Contractor's Testing, Adjusting, and Balancing (TAB) Specialist
C Contractor's Controls Representative
D Design Agency Representative
O Contracting Officer's Representative
U Using Agency's Representative

Appendices A and B shall be completed by the commissioning team. Acceptance by each commissioning team member of each Pre- Functional Performance Test Checklist item shall be indicated by initials and date unless an "X" is shown indicating that participation by that individual is not required. Acceptance by each commissioning team member of each functional performance test item shall be indicated by signature and date.

3.2 TESTS

The pre-functional performance test checklists and functional performance tests shall be performed in a manner that essentially duplicates the checking, testing, and inspection methods established in the related Sections. Where checking, testing, and inspection methods are not specified in other Sections, methods shall be established which will provide the information required. Testing and verification required by this section shall be performed during the Commissioning phase. Requirements in related Sections are independent from the requirements of this Section and shall not be used to satisfy any of the requirements specified in this Section. The Contractor shall provide all materials, services, and labor required to perform the pre- functional performance tests checks and functional performance tests. A functional performance test shall be aborted if any system deficiency prevents the successful completion of the test or if any participating non-Government commissioning team member of which participation is specified is not present for the test.

3.2.1 Pre-Functional Performance Test Checklists

Pre-Functional Performance Test Checklists shall be performed for the items indicated in Appendix A. Deficiencies discovered during these checks shall be corrected and re-inspected in accordance with the applicable contract requirements.

3.2.2 Functional Performance Tests

Functional Performance Tests shall be performed for the items indicated in Appendix B. Functional Performance Tests shall begin only after all Pre-Functional Performance Test Checklists have been successfully completed. Tests shall prove all modes of the sequences of operation, and shall verify all other relevant contract requirements. Tests shall begin with equipment or components and shall progress through subsystems to complete systems. Upon failure of any Functional Performance Test item, the Contractor shall correct all deficiencies in accordance with the applicable contract requirements. The item shall then be retested until it has been completed with no errors.

3.3 COMMISSIONING REPORT

The Commissioning Report shall consist of completed Pre- Functional Performance Test Checklists and completed Functional Performance Tests organized by system and by subsystem and submitted as one package. The Commissioning Report shall also include all HVAC systems test reports,

inspection reports (Preparatory, Initial and Follow-up inspections), start-up reports, TAB report, TAB verification report, Controls start-up test reports and Controls Performance Verification Test (PVT) report. The results of failed tests shall be included along with a description of the corrective action taken.

APPENDIX A

PRE-FUNCTIONAL PERFORMANCE TEST CHECKLISTS

Pre-Functional Performance Test Checklist - Multizone Air Handling Unit

For Air Handling Unit: _____

Checklist Item	A	M	E	T	C	O
Installation						
a. Inspection and access doors are operable and sealed.	___	___	X	___	X	___
b. Condensate drainage is unobstructed. (Visually verify pan drains completely by pouring a cup of water into drain pan.)	___	___	X	X	X	___
c. Fan belt adjusted.	___	___	X	___	X	___

Electrical	A	M	E	T	C	O
a. Power available to unit disconnect.	___	X	___	X	X	___
b. Power available to unit control panel.	___	X	___	X	X	___
c. Proper motor rotation verified.	___	X	___	___	X	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	X	___	X	X	___

Coils	A	M	E	T	C	O
a. Chilled water piping properly connected.	___	___	X	X	X	___
b. Hot water piping properly connected.	___	___	X	X	X	___

Controls	A	M	E	T	C	O
a. Control valves/actuators properly installed.	___	X	X	X	___	___
b. Control valves/actuators operable.	___	X	X	X	___	___
c. O/A dampers/actuators properly installed.	___	X	X	X	___	___
d. O/A dampers/actuators operable.	___	X	X	X	___	___

Pre-Functional Performance Test Checklist - Multizone Air Handling Unit (cont)

	A	M	E	T	C	O
e. Zone dampers/actuators properly installed & dampers leak checked.	___	X	X	X	___	___
f. Zone dampers/actuators operable.	___	X	X	X	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. Construction filters removed and replaced.	___	___	X	___	X	___
b. TAB report approved.		___	X	X	___	X

Pre-Functional Performance Test Checklist - Variable Volume Air Handling Unit

For Air Handling Unit: _____

Checklist Item	A	M	E	T	C	O
Installation						
a. Inspection and access doors are operable and sealed.	___	___	X	___	X	___
b. Condensate drainage is unobstructed. (Visually verify drainage by pouring a cup of water into drain pan.)	___	___	X	X	X	___
c. Fan belt adjusted.	___	___	X	___	X	___
Electrical	**A**	**M**	**E**	**T**	**C**	**O**
a. Power available to unit disconnect.	___	X	___	X	X	___
b. Power available to unit control panel.	___	X	___	X	X	___
c. Proper motor rotation verified.	___	X	___	___	X	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	X	___	X	X	___
Coils	**A**	**M**	**E**	**T**	**C**	**O**
a. Chilled water piping properly connected.	___	___	X	X	X	___
b. Hot water piping properly connected.	___	___	X	X	X	___

Pre-Functional Performance Test Checklist - Variable Volume Air Handling Unit

Controls	A	M	E	T	C	O
a. Control valves/actuators properly installed.	___	X	X	X	___	___
b. Control valves/actuators operable.	___	X	X	X	___	___
c. Dampers/actuators properly installed.	___	X	X	X	___	___
d. Dampers/actuators operable.	___	X	X	X	___	___
e. Verify proper location, installation and calibration of duct static pressure sensor.	___	X	X	X	___	___
f. Fan air volume controller operable.	___	X	X	X	___	___
g. Air handler controls system operational.	___	X	X	X	___	___

Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. Construction filters removed and replaced.	___	___	X	___	___	___
b. TAB report approved.	___	X	X	___	X	___

Pre-Functional Performance Test Checklist - VAV Terminal

For VAV Terminal: _____

Checklist Item	A	M	E	T	C	O
Installation						
a. Reheat coil connected to hot water pipe.	___	___	X	___	X	___
Controls	**A**	**M**	**E**	**T**	**C**	**O**
a. Cooling only VAV terminal controls set.	___	X	X	X	___	___
b. Cooling only VAV controls verified.	___	X	X	X	___	___
c. Reheat VAV terminal controls set.	___	X	X	X	___	___
d. Reheat terminal/coil controls verified.	___	X	X	X	___	___
Testing, Adjusting, and Balancing (TAB)	**A**	**M**	**E**	**T**	**C**	**O**
a. TAB report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Pumps

For Pump: _____

Checklist Item	A	M	E	T	C	O
Installation						
a. Piping system installed.	___	___	X	X	X	___
Electrical	**A**	**M**	**E**	**T**	**C**	**O**
a. Power available to pump disconnect.	___	X	___	X	X	___
b. Pump rotation verified.	___	X	___	X	X	___
c. Control system interlocks functional.	___	X	___	X	___	___
Testing, Adjusting, and Balancing (TAB)	**A**	**M**	**E**	**T**	**C**	**O**
a. Pressure/temperature gauges installed.	___	___	X	___	X	___
b. TAB Report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Centrifugal Chiller

For Chiller: _____

Checklist Item						
Installation	A	M	E	T	C	O
a. Chilled water connections properly piped.	___	___	X	___	___	___
b. Condenser water connections properly piped	___	___	X	___	___	___
c. Refrigerant leak detector installed.	___	___	___	___	___	___
d. Oxygen sensor installed and tested.	___	___	___	___	___	___
e. Mechanical room ventilation installed as specified.	___	___	___	___	___	___
Electrical	A	M	E	T	C	O
a. Power available to unit starter.	___	X	___	X	___	___
b. Power available to unit control panel.	___	X	___	X	___	___
c. Verify that power disconnect is located within sight of the unit it controls.	___	X	___	X	___	___
Controls	A	M	E	T	C	O
a. Factory startup and checkout complete.	___	___	X	X	___	___
b. Chiller safety/protection devices tested.	___	___	___	X	___	___
c. Chilled water flow switch installed and tested.	___	___	X	X	___	___
e. Chilled water pump interlock installed and tested.	___	___	___	X	___	___
g. Condenser water flow switch installed and tested.	___	___	___	X	___	___
i. Condenser water pump interlock installed and tested.	___	___	___	X	___	___

Pre-Functional Performance Test Checklist - Cooling Tower

For Cooling Tower: _____

Checklist Item						
Installation	A	M	E	T	C	O
a. Cooling tower properly piped.	___	___	X	X	___	___
b. Cooling tower fan drive adjusted.	___	___	___	___	X	___
c. Cooling tower makeup water supply piped.	___	___	X	X	___	___
d. Verify makeup control valve shutoff.	___	___	X	___	X	___
e. Fan lubricated and blade pitch adjusted.	___	___	X	___	X	___
Electrical	A	M	E	T	C	O
a. Power available to tower disconnect.	___	X	___	X	___	___
b. Power available to electric sump heater.	___	X	___	X	___	___
c. Control system interlocks functional.	___	___	___	X	___	___
d. Motor and fan rotation checked.	___	X	___	X	___	___
e. Verify that power disconnect is located within sight of the unit is controls.	___	X	___	X	___	___
Piping	A	M	E	T	C	O
a. Condenser water treatment functional.	___	___	X	X	X	___
b. All required temperature sensing wells, pressure ports and flow sensors have been installed for performance tests.	___	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB report approved.	___	___	X	___	X	_____

Pre-Functional Performance Test Checklist - Hot Water Boiler

For Boiler: _____

Checklist Item						
Installation	A	M	E	T	C	O
a. Boiler hot water piping installed.	___	___	X	___	___	___
b. Boiler makeup water piping installed.	___	___	X	___	___	___
c. Boiler gas piping installed.	___	___	X	X	X	___
Startup	A	M	E	T	C	O
a. Boiler safety/protection devices, including high temperature burner shut-off, low water cutoff, flame failure, pre- and post-purge, have been tested.	___	___	___	X	___	___
b. Verify that PRV rating conforms to boiler rating.	___	___	___	X	___	___
c. Boiler water treatment system functional.	___	___	X	X	___	___
d. Boiler startup and checkout complete.	___	___	X	X	___	___
e. Combustion efficiency demonstrated.	___	___	X	___	X	___
Electrical	A	M	E	T	C	O
a. Verify that power disconnect is located within sight of the unit served.	___	X	___	X	___	___
Controls	A	M	E	T	C	O
a. Hot water pump interlock installed and tested.	___	___	___	X	___	___
b. Hot water proof-of-flow switch installed and tested	___	___	X	X	___	___
c. Hot water heating controls operational.	___	___	X	X	___	___
Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Fan Coil Unit

For Fan Coil Unit: _____

Checklist Item						
Installation	**A**	**M**	**E**	**T**	**C**	**O**
a. Access doors/removable panels are operable and sealed.	___	___	X	___	X	___
b. Condensate drainage is unobstructed.	___	___	X	X	X	___
c. Fan belt adjusted.	___	___	X	___	X	___
Electrical	**A**	**M**	**E**	**T**	**C**	**O**
a. Power available to unit disconnect.	___	___	___	X	___	___
b. Power available to unit control panel.	___	___	___	X	___	___
c. Proper motor rotation verified.	___	___	___	___	X	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___
e. Power available to electric heating coil.	___	___	___	X	X	___
Coils	**A**	**M**	**E**	**T**	**C**	**O**
a. Chilled water piping properly connected.	___	___	X	X	X	___
b. Hot water piping properly connected.	___	___	X	___	___	___
Controls	**A**	**M**	**E**	**T**	**C**	**O**
a. Control valves/actuators properly installed.	___	___	X	___	___	___
b. Control valves/actuators operable.	___	___	X	X	___	___
c. Verify proper location and installation of thermostat.	___	___	X	___	___	___
Testing, Adjusting, and Balancing (TAB)	**A**	**M**	**E**	**T**	**C**	**O**
a. TAB Report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Unit Heater

For Unit Heater: _____

Checklist Item						
Installation	A	M	E	T	C	O
a. Hot water piping properly connected.	___	___	X	___	___	___
Electrical	A	M	E	T	C	O
a. Power available to unit disconnect.	___	___	___	X	___	___
b. Proper motor rotation verified.	___	___	___	X	X	___
c. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___
d. Power available to electric heating coil.	___	___	___	X	___	___
Controls	A	M	E	T	C	O
a. Control valves properly installed.	___	___	X	___	___	___
b. Control valves operable.	___	___	X	X	___	___
c. Verify proper location and installation of thermostat.	___	___	X	___	___	___
Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB Report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Exhaust Fan

For Exhaust Fan: _____

Checklist Item						
Installation	A	M	E	T	C	O
a. Fan belt adjusted.	___	___	X	___	X	___
Electrical	A	M	E	T	C	O
a. Power available to fan disconnect.	___	___	___	X	___	___
b. Proper motor rotation verified.	___	___	___	___	X	___
c. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___
Controls	A	M	E	T	C	O
a. Control interlocks properly installed.	___	___	___	X	___	___
b. Control interlocks operable.	___	___	___	X	___	___
c. Dampers/actuators properly installed.	___	___	X	___	___	___
d. Dampers/actuators operable.	___	___	X	___	___	___
e. Verify proper location and installation of thermostat.	___	___	X	___	___	___
Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB Report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - HVAC System Controls

For HVAC System: _____

Checklist Item						
Installation	A	M	E	T	C	O
a. Layout of control panel matches drawings.	___	___	X	X	___	___
b. Framed instructions mounted in or near control panel.	___	___	X	X	___	___
c. Components properly labeled (on inside and outside of panel).	___	___	X	X	___	___
d. Control components piped and/or wired to each labeled terminal strip.	___	___	X	X	___	___
e. EMCS connection made to each labeled terminal strip as shown.	___	___	X	X	___	___
f. Control wiring and tubing labeled at all terminations, splices, and junctions.	___	___	X	X	___	___
Main Power and Control Air						
a. 120 volt AC power available to panel.	___	___	___	X	___	___
b. 138 kPa gauge (20 psig) compressed air available to panel.	___	___	X	X	___	___
Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB Report submitted.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Make Up Air Handling Unit

For Air Handling Unit: _____

Checklist Item						
Installation	A	M	E	T	C	O
a. Inspection and access doors are operable and sealed.	___	___	X	___	X	___
b. Condensate drainage is unobstructed.	___	___	X	X	X	___
c. Fan belt adjusted.	___	___	X	___	X	___
Electrical	A	M	E	T	C	O
a. Power available to unit disconnect.	___	___	___	X	X	___
b. Power available to unit control panel.	___	___	___	X	___	___
c. Proper motor rotation verified.	___	___	___	___	X	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___
e. Power available to transformers.	___	___	___	X	___	___
Coils	A	M	E	T	C	O
a. Chilled water piping properly connected.	___	___	X	___	___	___
b. Hot water piping properly connected.	___	___	X	___	___	___
Controls	A	M	E	T	C	O
a. Control valves/actuators properly installed.	___	___	X	___	___	___
b. Control valves/actuators operable.	___	___	X	___	___	___
c. Dampers/actuators properly installed.	___	___	X	___	___	___
d. Dampers/actuators operable.	___	___	X	___	___	___
e. Verify proper location and installation of thermostat.	___	___	X	___	___	___
Testing, Adjusting, and Balancing (TAB)	A	M	E	T	C	O
a. TAB Report approved.	___	___	X	___	X	___

Pre-Functional Performance Test Checklist - Energy Recovery System

For Energy Recovery System: _____

Checklist Item						
Installation	A	M	E	T	C	O
a. Recovery system piping installed.	___	___	X	___	X	___
Startup	A	M	E	T	C	O
a. Startup and checkout complete.	___	___	X	X	X	___
Controls	A	M	E	T	C	O
a. Control valves/actuators properly installed.	___	___	X	___	___	___
b. Control valves/actuators operable.	___	___	X	___	___	___

- End of Appendix A -

APPENDIX B

FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

Functional Performance Test - Pump _____

NOTE: Prior to performing this test, for closed loop systems ensure that the system is pressurized and the make-up water system is operational, or for open loop systems ensure that the sumps are filled to the proper level.

1. Activate pump start using control system commands.

a. Verify correct operation in:

HAND_____ OFF_____ AUTO_____

b. Verify pressure drop across strainer:

Strainer inlet pressure _____ psig

Strainer outlet pressure _____ psig

c. Verify pump inlet/outlet pressure reading, compare to Testing, Adjusting, and Balancing (TAB) Report and pump design conditions.

	DESIGN	TAB	ACTUAL
Pump inlet pressure psig	_____	_____	_____
Pump outlet pressure psig	_____	_____	_____

d. Operate pump at shutoff and at 100 percent of designed flow when all components are in full flow. Plot test readings on pump curve and compare results against readings taken from flow measuring devices.

	SHUTOFF	100 percent
Pump inlet pressure psig	_____	_____
Pump outlet pressure psig	_____	_____
Pump flow rate gpm	_____	_____

	SETPOINT
Differential Pressure Transmitter	_____

Functional Performance Test (cont) - Pump _____

e. For variable speed pumps, operate pump at shutoff (shutoff to be done in manual on var1able speed drive at the minimum rpm that the system is being controlled at) and at minimum flow or when all components are in full by-pass. Plot test readings on pump curve and compare results against readings taken from flow measuring devices.

	SHUTOFF	100 percent
Pump inlet pressure psig	_____	_____
Pump outlet pressure psig	_____	_____
Pump flow rate gpm	_____	_____

	SETPOINT
Differential Pressure Transmitter	_____

2. Measure motor amperage each phase and voltage phase to phase and phase to ground for both the full flow and the minimum flow conditions. Compare amperage to nameplate FLA

a. Full flow:

Nameplate FLA _____

Amperage	Phase 1 _____	Phase 2_____	Phase 3_____
Voltage	Ph1-Ph2 _____	Ph1-Ph3_____	Ph2-Ph3_____
Voltage	Ph1-gnd _____	Ph2-gnd_____	Ph3-gnd_____

b. Minimum flow:

Amperage	Phase 1 _____	Phase 2_____	Phase 3_____
Voltage	Ph1-Ph2 _____	Ph1-Ph3_____	Ph2-Ph3_____
Voltage	Ph1-gnd _____	Ph2-gnd_____	Ph3-gnd_____

3. Note unusual vibration, noise, etc.

_____

_____

Functional Performance Test (cont) - Pump _____

4. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____
Contractor's Mechanical Representative	_____
Contractor's Electrical Representative	_____
Contractor's TAB Representative	_____
Contractor's Controls Representative	_____
Contracting Officer's Representative	_____
Design Agency Representative	_____
Using Agency's Representative	_____

Functional Performance Test - Centrifugal Chiller _____

Note: If water-cooled chiller perform in conjunction with Cooling Tower test.

1. Demonstrate operation of chilled water system as per specifications including the following: Start building air handler to provide load for chiller. Activate controls system chiller start sequence as follows:

a. Time of day startup program initiates chiller start: _____

b. Start condenser water pump and establish condenser water flow. Verify chiller condenser water proof-of-flow switch operation._____

c. Start chilled water pump and establish chilled water flow. Verify chiller chilled water proof-of-flow switch operation. _____

d. Verify control system energizes chiller start sequence._____

e. Verify chiller senses chilled water temperature above set point and control system activates chiller start. _____

f. Verify functioning of "soft start" sequence. _____

g. Record data in 2, 3 and 4 below on fully load chiller.

h. Shut off air handling equipment to remove load on chilled water system. Verify chiller shutdown sequence is initiated and accomplished after load is removed. _____

i. Restart air-handling equipment one minute after chiller shut down. Verify condenser water pump, cooling tower, and chiller restart sequence. _____

2. Verify chiller inlet/outlet pressure and flow reading, compare to Testing, Adjusting, and Balancing (TAB) Report, chiller design conditions, and chiller manufacturer's performance data.

	DESIGN	TAB REPORT	ACTUAL
Chiller inlet pressure psig	_____	_____	
Chiller outlet pressure psig	_____	_____	
Chiller flow GPM	_____	_____	_____

3. Measure chiller amperage each phase and voltage phase to phase and phase to ground for both the fully loaded condition.

				Motor F/L AMPS
Amperage	Phase 1 _____	Phase 2_____	Phase 3_____	_____
Voltage	Ph1-Ph2 _____	Ph1-Ph3_____	Ph2-Ph3_____	
Voltage	Ph1-gnd _____	Ph2-gnd_____	Ph3-gnd_____	

Functional Performance Test (cont) - Centrifugal Chiller _____

4. a. Record the following information: Design

Ambient dry bulb temperature _____ deg F _____
Entering chilled water temperature _____ deg F _____
Leaving chilled water temperature _____ deg F _____

b. Calculate chiller load at ambient conditions and compare to chiller rated capacity from manufacturer's literature. Calculated _____ Ton Rated _____ Ton.

5. Unusual vibration, noise, etc.

_____

_____

6. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Commissioning Specialist _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's TAB Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Design Agency Representative _____

Using Agency's Representative _____

Functional Performance Test - Cooling Tower _____

1. Demonstrate operation of the cooling tower as per specification and the following:

a. Activate cooling tower fan start using control system command. This should first start condenser water pump, establish flow, delay fan start, as specified, to equalize flow in distribution basin and sump. Verify fan start after timed delay._____

b. After chiller startup, control system should modulate bypass valve and two-speed fan motor to maintain condenser water set point. Verify function of bypass valve under varying loads. _____

c. Verify cooling tower interlock with chiller._____

d. Verify makeup water float valve is functioning. _____

e. Activate chemical treatment feed valve, verify makeup of chemical treatment system, pump, and controls._____

f. Record the following:

Entering water temperature _____ deg F
Leaving water temperature: _____ deg F
Measured water flow: _____ gpm
Entering air wet bulb temperature: _____ deg F

2. Compare results with test results from cooling tower specification test.

3.
a. Stop all building cooling equipment so that cooling tower pumps stop. Observe tower for at least 15 minutes and verify no overflow occurs_____.
b. Start cooling tower pumps in hand and observe pumps for air binding/cavitation , none allowed _____.

4.Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Commissioning Specialist _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's TAB Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Design Agency Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - VAV Terminals

The Contracting officer will select VAV terminals to be spot-checked during the functional performance test. The number of terminals selected shall not exceed 10 percent.

1. Functional Performance Test: Contractor shall demonstrate operation of selected VAV boxes as per specifications including the following:

a. Cooling only VAV boxes:

(1) Verify VAV box response to room temperature set point adjustment. Turn thermostat to 5 degrees F below ambient and measure maximum airflow. Turn thermostat to 5 degrees F above ambient and measure minimum airflow.

	Setting	Measured	Design
Maximum flow	_____	_____	_____ cfm
Minimum flow	_____	_____	_____ cfm

b. Cooling with reheat VAV boxes:

(1) Verify VAV box response to room temperature set point adjustment. Turn thermostat to 5 degrees F above ambient and measure maximum airflow. Turn thermostat to 5 degrees F below ambient and measure minimum airflow.

	Setting	Measured	Design
Maximum flow	_____	_____	_____ cfm
Minimum flow	_____	_____	_____ cfm

(2) Verify reheat coil operation range (full closed to full open) by turning room thermostat 5 degrees Fabove ambient _____.

With heating water system and boiler in operation providing design supply hot water temperature record the following:

Design HW supply temperature_____ deg F
Actual HW supply temperature_____ deg F
AHU supply air temperature_____ deg F
VAV supply air temperature_____ deg F
Calculate coil capacity and compare to design:
Design _____ BTU/hr Actual _____BTU/hr

Functional Performance Test Checklist (cont)- VAV Terminals

c. Parallel Fan powered VAV boxes:

(1) Verify VAV box responses to call for heating via set point adjustment. Change from cooling set point to heating set point. Verify cooling damper closes to minimum position, blower fan energizes according to sequence of operation, and upon further drop in space temperature, heating coil activation. _____

With heating water system in operation providing design supply hot water temperature record the following:

Design HW supply temperature_____ deg F
Actual HW supply temperature_____ deg F
AHU supply air temperature_____ deg F
VAV supply air temperature_____ deg F
Calculate coil capacity and compare to design:
Design _____ BTU/hr Actual _____BTU/hr

(2) Check primary air damper maximum/minimum flow settings and compare to actual measured flows.

	Setting	Measured	Design
Maximum flow	_____	_____	_____ cfm
Minimum flow	_____	_____	_____ cfm

(3) Check blower fan flow. _____ cfm

(4) Verify free operation of fan backdraft damper (insure no primary air is being discharged into plenum space).

---

d. Series Fan Powered VAV boxes

(1) Ensure VAV fan starts prior to AHU fan

(2) Verify VAV box response to sensor call for heating via set point adjustment. Change from cooling set point to heating set point. Verify cooling damper closes to minimum position and upon further drop in space temperature, heating coil activation. With heating water system and boiler in operation providing design supply hot water temperature record the following:

Design HW supply temperature_____ deg F
Actual HW supply temperature_____ deg F
AHU supply air temperature_____ deg F
VAV supply air temperature_____ deg F
Calculate coil capacity and compare to design:
Design _____ BTU/hr Actual _____BTU/hr

(3) Check primary air damper maximum/minimum flow settings and compare to actual measured flows.

	Setting	Measured	Design
Maximum flow	_____	_____	_____ cfm

Minimum flow _____ _____ _____ cfm

Functional Performance Test Checklist (cont)- VAV Terminals

(4) Verify that minimal primary air is discharging into the plenum space when in full cooling mode.

(5) Verify that no plenum air is being induced from the plenum space into the supply air during full cooling by measuring supply air temperature and comparing to primary air temperature

Primary air temp _____ deg F
Supply air temp _____ deg F

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____
Contractor's Mechanical Representative	_____
Contractor's Electrical Representative	_____
Contractor's TAB Representative	_____
Contractor's Controls Representative	_____
Contracting Officer's Representative	_____
Design Agency Representative	_____
Using Agency's Representative	_____

Functional Performance Test Checklist - Variable Volume Air Handling Unit

For Air Handling Unit: _____

1. Functional Performance Test: Contractor shall verify operation of air handling unit as per specification including the following:

a. Ensure that a slight negative pressure exists on inboard side of the outside air dampers throughout the operation of the dampers. Modulate OA, RA, and EA dampers from fully open to fully closed positions_____.

b. The following shall be verified supply and return fans operating mode is initiated:

(1) All dampers in normal position prior to fan start_____.

(2) All valves in normal position prior to fan start_____.

(3) System safeties allow start if safety conditions are met._____

(4) VAV fan controller shall "soft-start" fan. _____

(5) Modulate all VAV boxes to minimum air flow and verify that the static pressure does not exceed the high static pressure shutdown setpoint_____.

(6) Return all VAV boxes to auto _____.

c. Occupied mode of operation - economizer de-energized.

(1) Outside air damper at minimum position. _____

(2) Return air damper open. _____

(3) Relief air damper at minimum position. _____

(4) Chilled water control valve modulating to maintain leaving air temperature set point. Setpoint _____deg F Actual _____deg F

(5) Fan VAV controller receiving signal from duct static pressure sensor and modulating fan to maintain supply duct static pressure set point.
Setpoint _____inches-wg Actual _____inches-wg

d. Occupied mode of operation - economizer energized.

(1) Outside air damper modulated to maintain mixed air temperature set point. Setpoint _____deg F, Actual _____deg F, Outside air damper position _____%.

(2) Relief air damper modulates with outside air damper according to sequence of operation. Relief air damper position_____%.

(3) Chilled water control valve modulating to maintain leaving air temperature set point. Setpoint _____deg F Actual _____deg F

(4) Hot water control valve modulating to maintain leaving air

temperature set point. Setpoint _____deg F Actual _____deg F

Functional Performance Test Checklist (cont) - Variable Volume Air Handling Unit

(5) Fan VAV controller receives signal from duct static pressure sensor and modulates fan to maintain supply duct static pressure set point. Setpoint inches-wg_____ Actual inches-wg_____

e. Unoccupied mode of operation

(1) Observe fan starts when space temperature calls for heating and/or cooling. _____ Note: This does not apply to series boxes.
(2) All dampers in normal position. _____
(3) Verify space temperature is maintained as specified in sequence of operation. _____

f. The following shall be verified when the supply and return fans off mode is initiated:

(1) All dampers in normal position. _____

(2) All valves in normal position. _____

(3) Fan de-energizes. _____

g. Verify the chilled water coil control valve operation by setting all VAV's to maximum and minimum cooling.

Max Cooling

Supply air temp. _____ deg F Verify cooling valve operation_____.

Min cooling

Supply air temp. _____ deg F Verify cooling valve operation_____.

h. Verify safety shut down initiated by low temperature protection thermostat. _____

i. Verify occupancy schedule is programmed into time clock/UMCS_____.

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Commissioning Specialist _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's TAB Representative _____

Contractor's Controls Representative _____

Design Agency Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - Make Up Air Handling Unit

For Air Handling Unit: _____

1. Functional Performance Test: Contractor shall verify operation of air handling unit as per specification including the following:

a. Ensure that a slight negative pressure exists on inboard side of the outside air dampers throughout the operation of the dampers. Modulate OA, RA, and EA dampers from fully open to fully closed positions.

a. The following shall be verified when the supply and return fans operating mode is initiated:

(1) All dampers in normal position prior to fan start_____.

(2) All valves in normal position prior to fan start_____.

(3) System safeties allow start if safety conditions are met. ___

b. Occupied mode of operation.

(1) Outside air damper at minimum position._____

(2) Return air damper open._____

(3) Relief air damper at minimum position._____

(4) Chilled water control valve modulating to maintain space cooling temperature set point. Setpoint _____deg F Actual _____deg F

(5) Hot water control valve modulating to maintain space heating temperature set point input from outside air temperature controller. _____

Functional Performance Test Checklist (cont) - Make Up Air Handling Unit

c. The following shall be verified when the supply and return fans off mode is initiated:

(1) All dampers in normal position._____

(2) All valves in normal position._____

(3) Fan de-energizes. _____

d. Verify cooling coil and heating coil operation by varying thermostat set point from cooling set point to heating set point and returning to cooling set point_____.

e. Verify safety shut down initiated by low temperature protection thermostat_____.

f. Verify occupancy schedule is programmed into time clock/UMCS_____.

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____
Contractor's Mechanical Representative	_____
Contractor's Electrical Representative	_____
Contractor's TAB Representative	_____
Contractor's Controls Representative	_____
Design Agency Representative	_____
Contracting Officer's Representative	_____
Using Agency's Representative	_____

Functional Performance Test Checklist - Multi-zone Air Handling Unit

For Air Handling Unit: _____

1. Functional Performance Test: Contractor shall verify operation of air handling unit as per specification including the following:

a. Ensure that a slight negative pressure exists on inboard side of the outside air dampers throughout the operation of the dampers. Modulate OA, RA, and EA dampers from fully open to fully closed positions.

b. The following shall be verified when the supply and return fans operating mode is initiated:

(1) All dampers in normal position. _____

(2) All valves in normal position. _____

(3) System safeties allow start if safety conditions are met. ___

b. Occupied mode of operation - economizer de-energized.

(1) Outside air damper at minimum position. _____

(2) Return air damper open. _____

(3) Relief air damper at minimum position. _____

(4) Chilled water control valve modulating to maintain cold deck supply air temperature set point. Setpoint _____deg F Actual _____deg F

(5) Hot water control valve modulating to maintain hot deck supply air temperature set point input from outside air temperature controller. Setpoint _____deg F Actual _____deg F O/A _____deg F

c. Occupied mode of operation - economizer energized. Note outside air and return air temperature sensors may need to be simulated.

(1) Outside air damper modulates to maintain mixed air temperature set point. Setpoint _____deg F Actual _____deg F Return Air Temperature _____deg F Outside Air Temperature _____deg F

(2) Relief air damper modulates with outside air damper according to sequence of operation._____

(3)Chilled water control valve modulating to maintain cold deck supply air temperature set point. Setpoint _____deg F Actual _____deg F

(4)Hot water control valve modulating to maintain hot deck supply air temperature set point input from outside air temperature controller. Setpoint _____deg F Actual _____deg F O/A _____ deg F
Return temperature sensors to normal operation.

Functional Performance Test Checklist (cont) - Multi-zone Air Handling Unit

d. Unoccupied mode of operation note time clock and space temperature sensor may require simulation.
(4) Observe fan starts when space temperature calls for heating/cooling.
(5) All dampers in normal position. _____
(6) Verify low limit space temperature is maintained as specified in sequence of operation. _____

e. The following shall be verified when the supply and return fans off mode is initiated:

(1) All dampers in normal position. _____

(2) All valves in normal position. _____

(3) Fan de-energizes. _____
Note: return time clock and space temperature sensors to normal operation.

f. Verify zone damper operation by varying zone thermostat set points from cooling set point to heating set point and returning to cooling set point. _____

g. Verify safety shut down initiated by low temperature protection thermostat. _____

h. Index room thermostats to full cooling then to full heating. Measure and record cold deck, hot deck, and supply air temperatures and determine damper leakage for a minimum of 2 zones.

Cold deck temperature _____ _____ degrees F
Hot deck temperature _____ _____ degrees F

Zone _____
Zone _____ Supply Air Temperature at Max Cooling _____deg F
Zone _____ Supply Air Temperature at Max Heating _____deg F
Zone ____Hot Deck Damper leakage at Max cooling _____CFM
Zone ____Cold Deck Damper leakage at Max heating _____CFM

Zone _____
Zone _____ Supply Air Temperature at Max Cooling _____deg F
Zone _____ Supply Air Temperature at Max Heating _____deg F
Zone ____Hot Deck Damper leakage at Max cooling _____CFM
Zone ____Cold Deck Damper leakage at Max heating _____CFM

i. Verify occupancy schedule is programmed into time clock/UMCS_____.

Functional Performance Test Checklist (cont) - Multi-zone Air Handling Unit

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Commissioning Specialist _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's TAB Representative _____

Contractor's Controls Representative _____

Design Agency Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - Hot Water Boiler

For Boiler: _____

1. Functional Performance Test: Contractor shall demonstrate operation of hot water system as per specifications including the following: Start building heating equipment to provide load for boiler. Activate controls system boiler start sequence as follows.

a. Start hot water pump and establish hot water flow. Verify boiler hot water proof-of-flow switch operation. _____

b. Verify control system energizes boiler start sequence. _____

c. Verify boiler senses hot water temperature below set point and control system activates boiler start. Setpoint_____deg F

2. Verify boiler inlet/outlet pressure reading, compare to Test and Balance (TAB) Report, boiler design conditions, and boiler manufacturer's performance data.

	DESIGN	SYSTEM TEST	ACTUAL
Boiler inlet water temperature deg F	_____	_____	_____
Boiler outlet water temperature deg F	_____	_____	_____
Boiler outlet pressure psig	_____	_____	_____
Boiler flow rate gpm	_____	_____	_____
Flue-gas temperature at boiler outlet deg F		_____	_____
Percent carbon dioxide in flue-gas		_____	_____
Draft at boiler flue-gas exit inches-wg		_____	_____
Stack emission pollutants concentration	_____	_____	_____
Fuel type	_____	_____	_____
Combustion efficiency	_____	_____	_____

3. Record the following information:

Ambient dry bulb temperature to determine reset schedule_____degrees F
Building Entering hot water temperature _____degrees F
Building Leaving hot water temperature _____ degrees F

4. Verify temperatures in item 3 are in accordance with the reset schedule. _____

5. Verify proper operation of boiler safeties. _____
   a. Low water_____
   b. Water flow____
   c. Flame failure____
   d. Pilot failure____
   e. Pre and Post Purge failure____
   f. Pressure relief___
   g. High temperature____

6. Shut off building heating equipment to remove load on hot water system. Verify boiler shutdown sequence is initiated and accomplished after load is removed. _____

Functional Performance Test Checklist (cont) - Hot Water Boiler

7. Unusual vibration, noise, etc.

_____

_____

8. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____
Contractor's Mechanical Representative	_____
Contractor's Electrical Representative	_____
Contractor's TAB Representative	_____
Contractor's Controls Representative	_____
Design Agency Representative	_____
Contracting Officer's Representative	_____
Using Agency's Representative	_____

Functional Performance Test Checklist - Fan Coil Units

The Contracting Officer will select fan coil units to be spot-checked during the functional performance test. The number of terminals shall not exceed 10 percent. Hot water and chilled water systems must be in operation providing design water temperatures.

1. Functional Performance Test: Contractor shall demonstrate operation of selected fan coils as per specifications including the following:

a. Cooling only fan coils:

(1) Verify fan coil unit response to room temp set point adjustment.

1. Check blower fan airflow. _____ cfm
2. Check cooling coil water flow. _____ gpm
3. Verify proper operation of cooling water control valve._____
4. Cooling mode inlet air temperature _____deg F
5. Cooling mode outlet air temperature_____deg F
6. Calculate coil sensible capacity and compare to design: Calculated _____BTU/hr Design_____BTU/hr

b. Cooling/heating fan coils:

(1) Verify fan coil unit response to room temp set point adjustment.

1. Check blower fan airflow. _____ cfm
2. Check cooling coil water flow. _____ gpm
3. Verify proper operation of cooling water control valve. ____
4. Check cooling mode inlet air temperature. _____deg F
5. Check cooling mode outlet air temperature. _____degF
6. Calculate cooling coil sensible capacity and compare to design:
7. Calculated _____BTU/hr Design_____BTU/hr
8. Check heating coil water flow. _____ gpm
9. Verify proper operation of heating water control valve. _____
10. Check heating mode inlet air temperature. _____ degF
11. Check heating mode outlet air temperature. _____degF
12. Calculate heating coil capacity and compare to design: Calculated_____BTU/hr or watts design_____BTU/hr or watts

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Commissioning Specialist _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's TAB Representative _____

Contractor's Controls Representative _____

Design Agency Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

Functional Performance Test Checklist - Unit Heaters

The Contracting Officer will select unit heaters to be spot-checked during the functional performance test. The number of terminals shall not exceed 10 percent. Hot water systems {for hot water unit heaters} must be in operation and supplying design hot water supply temperature water.

1. Functional Performance Test: Contractor shall demonstrate operation of selected unit heaters:

a. Verify unit heater response to room temperature set point adjustment._____
b. Check heating mode inlet air temperature. _____ deg F
c. Check heating mode outlet air temperature. _____ deg F
d. Record manufacturer's submitted fan capacity _____cfm
e. Calculate unit heater capacity using manufacturer's fan capacity and recorded temperatures and compare to design.
i. Calculated_____BTU/hr or watts Design_____BTU/hr or Watts

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____
Contractor's Mechanical Representative	_____
Contractor's Electrical Representative	_____
Contractor's TAB Representative	_____
Contractor's Controls Representative	_____
Design Agency Representative	_____
Contracting Officer's Representative	_____
Using Agency's Representative	_____

Functional Performance Test Checklist - HVAC Controls

For HVAC System: _____

The Contracting Officer will select HVAC control systems to undergo functional performance testing. The number of systems shall not exceed 10 percent. Perform this test simultaneously with FPT for AHU or other controlled equipment.

1. Functional Performance Test: Contractor shall verify operation of HVAC controls by performing the Performance Verification Test {PVT} test for that system. Contractor to provide blank PVT test procedures previously done by the controls Contractor.

2. Verify interlock with UMCS system_____.

3. Verify all required I/O points function from the UMCS system_____.

4. Certification: We the undersigned have witnessed the Performance Verification Test and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____
Contractor's Mechanical Representative	_____
Contractor's Electrical Representative	_____
Contractor's TAB Representative	_____
Contractor's Controls Representative	_____
Design Agency Representative	_____
Contractor's Officer's Representative	_____
Using Agency's Representative	_____

Functional Performance Test Checklist - Energy Recovery System

For Energy Recovery System: _____

1. Functional Performance Test: Contractor shall demonstrate operation of energy recovery system as per specifications including the following: Start equipment to provide energy source for recovery system.

a. Verify energy source is providing recoverable energy._____

b. Verify recovery system senses available energy and activates._____

2. Verify recovery system inlet/outlet readings, compare to design conditions and manufacturer's performance data.

	Design	Actual
Primary loop inlet temp degrees F	_____	_____
Primary loop outlet temp degrees /F	_____	_____
Primary loop flow rate cfm	_____	_____
Secondary loop inlet temp degrees F	_____	_____
Secondary loop outlet temp degrees F	_____	_____
Secondary loop flow rate cfm	_____	_____
Primary loop energy BTU/hr	_____	_____
Secondary loop energy BTU/hr	_____	_____

3. Verify that recovery system deactivates when recoverable energy is no longer available. _____

4. Check and report unusual vibration, noise, etc.

_____

_____

5. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

	Signature and Date
Contractor's Commissioning Specialist	_____
Contractor's Mechanical Representative	_____
Contractor's Electrical Representative	_____
Contractor's TAB Representative	_____
Contractor's Controls Representative	_____
Design Agency Representative	_____
Contractor's Officer's Representative	_____
Using Agency's Representative	_____

- End of Appendix B -

-- End of Section --

SECTION 23 09 23

DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 500-D	(1998) Laboratory Methods of Testing Dampers for Rating

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135	(2004; Int 1 thru 5 2004; Addenda A 2004; Errata 2005; Int 6 thru 15 2005; Int 16 thru 18 2006; Addenda C 2006; Addenda D 2006; Errata to Addenda D 2006; Int 19 thru 22 2007; Addenda F 2007; Addenda E 2007; Errata 2007, Errata 2008, Errata 2008; Int 23 thru 28 2008; Addenda M 2008) BACnet
ASHRAE FUN IP	(2005) Fundamentals Handbook, I-P Edition

ASME INTERNATIONAL (ASME)

ASME B16.15	(2006) Cast Bronze Threaded Fittings Classes 125 and 250
ASME B16.34	(2004) Valves - Flanged, Threaded and Welding End
ASME B40.100	(2006) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A 269	(2007a) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM B 88	(2003) Standard Specification for Seamless Copper Water Tube
ASTM B 88M	(2005) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM D 1693	(2007) Standard Test Method for Environmental Stress-Cracking of Ethylene

	Plastics
ASTM D 635	(2006) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1B	(2002) Control Network Protocol Specification
CEA-709.3	(1999) Free-Topology Twisted-Pair Channel Specification
CEA-852-A	(2004) Tunneling Component Network Protocols Over Internet Protocol Channels

FLUID CONTROLS INSTITUTE (FCI)

FCI 70-2	(2006) Control Valve Seat Leakage

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002) IEEE Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE Std 142	(1991; Errata 2006) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book (Color Book Series)

LONMARK INTERNATIONAL (LonMark)

LonMark Interoperability Guide	(2002) LonMark Application-Layer Interoperability Guide; Version 3.3
LonMark XIF Guide	(2001) LonMark External Interface File Reference Guide; Revision 4.0B

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2003) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2007; AMD 1 2008) National Electrical Code - 2008 Edition
NFPA 90A	(2008) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 1585	(1998; Rev thru May 2006) UL Standard for Safety Class 2 and Class 3 Transformers - Fourth Edition
UL 555	(2006) Standard for Fire Dampers
UL 555S	(1999; Rev thru Jul 2006) Smoke Dampers
UL 916	(1998; Rev thru Mar 2006) Energy Management Equipment
UL 94	(1996; Rev thru Jun 2006) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 DEFINITIONS

The following list of definitions may contain terms not found elsewhere in the Section but are included here for completeness.

a. Application Specific Controller: A device that is furnished with a pre-established built in application that is configurable but not re-programmable. An ASC has a fixed factory-installed application program (i.e Program ID) with configurable settings.

b. Binary: A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level. 'Digital' is sometimes used interchangeably with 'binary'.

c. Binding: The act of establishing communications between CEA-709.1B devices by associating the output of a device to the input of another.

d. Building Control Network: The CEA-709.1B control network installed under this Section, consisting of a backbone and one or more local control busses.

e. Building Point of Connection (BPOC): The BPOC is the point of connection between the UMCS network backbone (an IP network) and the building control network backbone. The hardware at this location, that provides the connection is referred to as the BPOC Hardware. In general, the term "BPOC Location" means the place where this connection occurs, and "BPOC Hardware" means the device that provides the connection. Sometimes the term "BPOC" is used to mean either and its actual meaning (i.e. location or hardware) is determined by the context in which it is used.

f. Channel: A portion of the control network consisting of one or more segments connected by repeaters. Channels are separated by routers. The device quantity limitation is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 128 devices per channel.

g. Configuration Parameter: Controller setting usually written to EEPROM. Also see 'Standard Configuration Parameter Type (SCPT)'

h. Control Logic Diagram: A graphical representation of control logic for multiple processes that make up a system.

i. Domain: A grouping of up to 32,385 nodes that can communicate directly with each other. (Devices in different domains cannot communicate directly with each other.) Part of the Node Addressing scheme.

j. Explicit Messaging: A method of communication between devices where each message contains a message code that identifies the type of message and the devices use these codes to determine the action to take when the message is received. These messages are non-standard and often vendor (application) dependent.

k. External Interface File (XIF): A file which documents a device's external interface, specifically the number and types of LonMark objects; the number, types, directions, and connection attributes of network variables; and the number of message tags.

l. Functional Profile: The description of one or more LonMark Objects used to classify and certify devices.

m. Gateway: A device that translates from one protocol to another. Gateways are also called Communications Bridges or Protocol Translators.

n. General Purpose Programmable Controller (GPPC): Unlike an ASC, a GPPC is not furnished with a fixed application program. A GPPC can be (re-)programmed, usually using vendor-supplied software.

o. LonMark Object: A collection of network variables, configuration parameters, and associated behavior defined by LonMark International and described by a Functional Profile. Defines how information is exchanged between devices on a network (inputs from and outputs to the network).

p. LNS Plug-in: Software which runs in an LNS compatible software tool. Device configuration plug-ins provide a 'user friendly' interface to configuration parameters.

q. LonMark: See LonMark International. Also, a certification issued by LonMark International to CEA-709.1B devices.

r. LonMark International: Standards committee consisting of numerous independent product developers and systems integrators dedicated to determining and maintaining the interoperability guidelines for the LonWorks industry. Maintains guidelines for the interoperability of CEA-709.1B devices and issues the LonMark Certification for CEA-709.1B devices.

s. LonMark Interoperability Association: See 'LonMark International'.

t. LonWorks: The overall communications technology, developed by Echelon Corporation, for control systems. The term is often used to refer to the technology in general, and may include reference to any/all of the: protocol, network management, and interoperability guidelines where the technology is based on the CEA-709.1B protocol and

employs interoperable devices along with the capability to openly manage these devices (via multiple vendors) using a network configuration (or service) tool.

u. LonWorks Network Services (LNS): A network management and database standard for CEA-709.1B devices.

v. Monitoring and Control (M&C) Software: The UMCS 'front end' software which performs supervisory functions such as alarm handling, scheduling and data logging and provides a user interface for monitoring the system and configuring these functions.

w. Network Variable: See 'Standard Network Variable Type (SNVT)'.

x. Network Configuration Tool: The software used to configure the control network and set device configuration properties. This software creates and modifies the control network database (LNS Database).

y. Node: A device that communicates using the CEA-709.1B protocol and is connected to an CEA-709.1B network.

z. Node Address: The logical address of a node on the network. Variations in node addressing are possible, but the 'Domain, Subnet, Node' format is the established standard for this specification.

aa. Node ID: A unique 48-bit identifier assigned (at the factory) to each CEA-709.1B device, sometimes called the Neuron ID.

bb. Program ID: An identifier (number) stored in the device (usually EEPROM) that identifies the node manufacturer, functionality of device (application & sequence), transceiver used, and the intended device usage.

cc. Repeater: A device that connects two control network segments and retransmits all information received on one side onto the other.

dd. Router: A device that connects two channels and controls traffic between the channels by retransmitting signals received from one subnet onto the other based on the signal destination. Routers are used to subdivide a control network and to control bandwidth usage.

ee. Segment: A 'single' section of a control network that contains no repeaters or routers. The device quantity limitation is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 64 devices per segment.

ff. Service Pin: A hardware push-button on a device which causes the device to broadcast a message (over the control network) containing its Node ID and Program ID. This broadcast can also be initiated via software.

gg. Standard Configuration Parameter Type (SCPT): Pronounced 'skip-it'. A standard format type (maintained by LonMark International) for Configuration Parameters.

hh. Standard Network Variable Type (SNVT): Pronounced 'snivet'. A standard format type (maintained by LonMark International) used to define data information transmitted and received by the individual nodes. The term SNVT is used in two ways. Technically it is the

acronym for Standard Network Variable Type, and is sometimes used in this manner. However, it is often used to indicate the network variable itself (i.e. it can mean "a network variable of a standard network variable type"). In general, the intended meaning should be clear from the context.

ii. Subnet: Consists of a logical (not physical) grouping of up to 127 nodes, where the logical grouping is defined by node addressing. Part of the Node Addressing scheme.

jj. TP/FT-10: A Free Topology Twisted Pair network defined by CEA-709.3. This is the most common media type for an ANSI-709.1 control network.

kk. UMCS Network: An IP network connecting multiple building level control networks using the CEA-852-A standard.

ll. User-defined Configuration Parameter Type (UCPT): Pronounced 'u-keep-it'. A Configuration Parameter format type that is defined by the device manufacturer.

mm. User-defined Network Variable Type (UNVT): A network variable format defined by the device manufacturer. Note that UNVTs create non-standard communications (other vendor's devices may not correctly interpret it) and may close the system and therefore are not permitted by this specification.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.

a. Technical data packages consisting of technical data and computer software (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications shall be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered 'shop drawings' under the Federal Acquisition Regulation Supplement (FARS) and shall contain no proprietary information and be delivered with unrestricted rights.

b. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES, the CONTRACT CLAUSES and DD Form 1423 and according to the sequencing specified in paragraph PROJECT SEQUENCING:

SD-02 Shop Drawings

DDC Contractor Design Drawings; G, DO

DDC Contractor Design Drawings shall be submitted in hard copy and on CDROM in AutoCAD format.

Final As-Built Drawings; G, DO

Final As-Built Drawings shall be submitted in hard copy and on

CDROM in AutoCAD format.

SD-03 Product Data

Manufacturer's Catalog Data; G, DO

Product specific catalog cuts shall be submitted for each product provided under this specification.

Programming Software; G, DO

The most recent version of the Programming software for each type (manufacturer and model) of General Purpose Programmable Controller (GPPC) shall be submitted as a Technical Data Package and shall be licensed to the project site. Software shall be submitted on CD-ROM and 8 hard copies of the software user manual shall be submitted for each piece of software provided.

GPPC Application Programs; G, DO

All installed GPPC Application Programs shall be submitted on CD-ROM as a Technical Data Package. The CD-ROM shall include a list or table of contents clearly indicating which application program is associated with each device. 2 copies of the GPPC Application Program's CD-ROM shall be submitted.

LNS Database; G, DO

Two copies of the LNS Database for the complete control network provided under this specification shall be submitted as a Technical Data Package. Each copy shall be on CD-ROM and shall be clearly marked identifying it as the LNS Database for the work covered under this specification and with the date of the most recent database modification.

LNS Plug-in; G, DO

LNS Plug-ins for each Application Specific Controller shall be submitted as a Technical Data Package. LNS Plug-ins distributed under a license shall be licensed to the project site. Plug-ins shall be submitted on CD-ROM. Hard copy manuals, if available, shall be submitted for each plug-in provided.

SD-05 Design Data

Network Bandwidth Usage Calculations; G, DO

Four copies of the Network Bandwidth Usage Calculations shall be submitted.

SD-06 Test Reports

Start-Up and Start-Up Testing Report; G, DO

Four copies of the Start-Up and Start-Up Testing Report shall be submitted. The Start-Up and Testing report may be submitted as a Technical Data Package.

PVT Procedures; G, DO

Four copies of the PVT Procedures shall be submitted. The PVT Procedures may be submitted as a Technical Data Package.

PVT Report; G, DO

Four copies of the PVT Phase Report shall be submitted. The PVT Phase Report may be submitted as a Technical Data Package.

Pre-Construction QC Checklist; G, DO

Four copies of the Pre-Construction QC Checklist shall be submitted.

Post-Construction QC Checklist; G, DO

Four copies of the Post-Construction QC Checklist shall be submitted.

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G, DO

2 copies of the Operation and Maintenance Instructions, indexed and in booklet form shall be submitted. The Operation and Maintenance Instructions shall be a single volume or in separate volumes, and may be submitted as a Technical Data Package.

Training Documentation; G, DO

Training manuals shall be delivered for each trainee on the Course Attendee List with 2 additional copies delivered for archival at the project site. 2 copies of the Course Attendee List shall be delivered with the archival copies. The Training Documentation may be submitted as a Technical Data Package.

SD-11 Closeout Submittals

Closeout QC Checklist; G, DO

Four copies of the Closeout QC Checklist shall be submitted.

1.4 SYSTEM DESCRIPTION

The Direct Digital Control (DDC) system shall be a complete system suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and shown.

1.4.1 System Requirements

Systems installed under this guide specification shall have the following characteristics:.

a. The DDC system shall be compatible with the existing base-wide Energy management & Control System (EMCS) front end located at 37th CES, Building 5595, Room 111. The building automation & control system (BACS) shall utilize intelligent distributed control modules, communicating over a controller network in accordance with ASHRAE 135. The system shall provide the Direct Digital Control (DDC), Energy

Management, and Building Automation functions for complete operation of th heating, ventilation, and air conditioning (HVAC) systems and other energy systems as described on the drawings. The BACS shall provide communication and full programming and software as required to insure communication with the Johnson Controls, incorporated (JCI) Metasys front end. Provide NCU, VMA, and DX9100 controllers as manufactured by JCI or fully compatible equipment, including any and all programming, software, etc. to insure communication with Metasys front end. Equipment, such as the chillers, boilers, and water softening system, shall have packaged microprocessor controls provided by the manufacturer. This equipment shall be enabled/disabled and monitored by the EMCS system through DDC control. Air terminal units shall be equipped with factory mounted direct digital unitary controllers provided by the same manufacturer as the air handling unit DDC system.

b. The hardware shall perform the control sequences as specified and shown to provide control of the equipment as specified and shown.

c. Control sequence logic shall reside in DDC hardware in the building. The building control network shall not be dependent upon connection to a Utility Monitoring and Control System (UMCS) for performance of control sequences in this specification. The hardware shall, to the greatest extent practical, perform the sequences without reliance on the building network.

d. The hardware shall be installed such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.

e. All necessary documentation, configuration information, configuration tools, programs, drivers, and other software shall be licensed to and otherwise remain with the Government such that the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor.

f. The Contractor shall provide sufficient documentation and data, including rights to documentation and data, such that the Government or their agents can execute work to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor.

g. Hardware shall be installed and configured such that the Government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the Contractor.

h. Control hardware shall be installed and configured to provide all input and output Standard Network Variables (SNVTs) as shown and as needed to meet the requirements of this specification.

i. All DDC devices installed under this specification shall communicate via CEA-709.1B. The control system shall be installed such that a SNVT output from any node on the network can be bound to any other node in the domain.

1.4.2 Verification of Dimensions

After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting

Officer of any discrepancy before performing any work.

1.4.3 Drawings

The Government will not indicate all offsets, fittings, and accessories that may be required on the drawings. The Contractor shall carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, shall arrange such work accordingly, and shall provide all work necessary to meet such conditions.

1.5 PROJECT SEQUENCING

TABLE I: PROJECT SEQUENCING lists the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3: EXECUTION (denoted by an 'E' in the 'TYPE' column).

a. Sequencing for submittals: The sequencing specified for submittals is the deadline by which the submittal shall be initially submitted to the Government. Following submission there will be a Government review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Government, the Contractor shall revise the submittal and resubmit it to the Government within 14 days of notification that the submittal has been rejected. Upon resubmittal there shall be an additional Government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.

b. Sequencing for Activities: The sequencing specified for activities indicates the earliest the activity may begin.

c. Abbreviations: In TABLE I the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

TABLE I. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
1	S	Existing Conditions Report	
2	S	DDC Contractor Design Drawings	
3	S	Manufacturer's Catalog Data	
4	S	Network Bandwidth Usage Calculations	
5	S	Pre-construction QC Checklist	
6	E	Install Building Control System	AAO #1 thru #5
7	E	Start-Up and Start-Up Testing	ACO #6
8	S	Post-Construction QC Checklist	7 days ACO #7
9	S	Programming Software	7 days ACO #7
10	S	XIF Files	7 days ACO #7
11	S	LNS Plug-ins	7 days ACO #7
12	S	Start-Up and Start-Up Testing Report	7 days ACO #7
13	S	Draft As-Built Drawings	7 days ACO #7
14	S	PVT Procedures	7 days before schedule start of #15 and AAO #12
15	E	PVT	AAO #13 and #14

TABLE I. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
16	S	PVT Report	7 days ACO #15
17	S	GPPC Application Programs	7 days AAO #16
18	S	LNS Database	7 days AAO #16
19	S	Final As-Built Drawings	7 days AAO #16
20	S	O&M Instructions	AAO #19
21	S	Training Documentation	AAO #12 and 7 days before scheduled start of #22
22	E	Training	AAO #20 and #21
23	S	Closeout QC Checklist	ACO #22

1.6 QUALITY CONTROL (QC) CHECKLISTS

The Contractor's Chief Quality Control (QC) Representative shall complete the QC Checklist in APPENDIX A and submit a Pre-Construction QC Checklist, Post-Construction QC Checklist and a Closeout QC Checklist as specified. The QC Representative shall verify each item in the Checklist and initial in the provided area to indicate that the requirement has been met. The QC Representative shall sign and date the Checklist prior to submission to the Government.

1.7 DELIVERY AND STORAGE

Products shall be stored with protection from the weather, humidity, and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer.

1.8 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

The HVAC control System Operation and Maintenance Instructions shall include:

a. "Manufacturer Data Package 3" as specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA for each piece of control equipment.

b. HVAC control system sequences of operation formatted as specified.

c. Procedures for the HVAC system start-up, operation and shut-down including the manufacturer's supplied procedures for each piece of equipment, and procedures for the overall HVAC system.

d. As-built HVAC control system detail drawings formatted as specified.

e. Printouts of configuration settings for all devices.

f. Routine maintenance checklist. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all installed devices, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.

g. Qualified service organization list.

h. Start-Up and Start-Up Testing Report.

i. Performance Verification Test (PVT) Procedures and Report.

1.9 MAINTENANCE AND SERVICE

Services, materials and equipment shall be provided as necessary to maintain the entire system in an operational state as specified for a period of one year after successful completion and acceptance of the Performance Verification Test. Impacts on facility operations shall be minimized.

1.9.1 Description of Work

The adjustment and repair of the system shall include the manufacturer's required sensor and actuator (including transducer) calibration, span and range adjustment.

1.9.2 Personnel

Service personnel shall be qualified to accomplish work promptly and satisfactorily. The Government shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

1.9.3 Scheduled Inspections

Two inspections shall be performed at six-month intervals and all work required shall be performed. Inspections shall be scheduled in June and December. These inspections shall include:

a. Visual checks and operational tests of equipment.

b. Fan checks and filter changes for control system equipment.

c. Clean control system equipment including interior and exterior surfaces.

d. Check and calibrate each field device. Check and calibrate 50 percent of the total analog inputs and outputs during the first inspection. Check and calibrate the remaining 50 percent of the analog inputs and outputs during the second major inspection. Certify analog test instrumentation accuracy to be twice the specified accuracy of the device being calibrated. Randomly check at least 25 percent of all digital inputs and outputs for proper operation during the first inspection. Randomly check at least 25 percent of the remaining digital inputs and outputs during the second inspection.

e. Run system software diagnostics and correct diagnosed problems.

f. Resolve any previous outstanding problems.

1.9.4 Scheduled Work

This work shall be performed during regular working hours, Monday through Friday, excluding Federal holidays.

1.9.5 Emergency Service

The Government will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the system. A telephone number where the service supervisor can be reached at all times shall be provided. Service personnel shall be at the site within 24 hours after receiving a request for service. The control system shall be restored to proper operating condition as required.

1.9.6 Operation

Scheduled adjustments and repairs shall include verification of the control system operation as demonstrated by the applicable tests of the performance verification test.

1.9.7 Records and Logs

Dated records and logs shall be kept of each task, with cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain initial analog span and zero calibration values and digital points. Complete logs shall be kept and shall be available for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

1.9.8 Work Requests

Each service call request shall be recorded as received and shall include its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. A record of the work performed shall be submitted within 5 days after work is accomplished.

1.9.9 System Modifications

Recommendations for system modification shall be submitted in writing. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the Operations and Maintenance Instructions, and other documentation affected.

1.10 SURGE PROTECTION

1.10.1 Power-Line Surge Protection

Equipment connected to ac circuits shall be protected against or withstand power-line surges. Equipment protection shall meet the requirements of IEEE C62.41.1, IEEE C62.41.2. Fuses shall not be used for surge protection.

1.10.2 Surge Protection for Transmitter and Control Wiring

DDC hardware shall be protected against or withstand surges induced on control and transmitter wiring installed outdoors and as shown. The equipment protection shall be protected against the following two waveforms:

a. A waveform with a 10-microsecond rise time, a 1,000-microsecond decay time and a peak current of 60 amps.

b. A waveform with an 8-microsecond rise time, a 20-microsecond decay time and a peak current of 500 amperes.

1.11 INPUT MEASUREMENT ACCURACY

Sensors, transmitters and DDC Hardware shall be selected, installed and configured such that the maximum error of the measured value at the SNVT output of the DDC hardware is less than 150% of the maximum allowable error specified for the sensor or instrumentation.

1.12 BUILDING CONTROL NETWORK

The building control network shall consist of a backbone and one or more local control busses as specified.

1.12.1 Backbone Media

The backbone shall be a TP/FT-10 network in accordance with CEA-709.3 or an IP network as specified in Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEMS according to the following criteria:

a. The backbone shall be an IP network as specified in Section 25 10 10 if both of the following conditions are met:

(1) the Network Bandwidth Calculations for a heavily loaded network show that more than 70% of the 78 kbps (kilobits per second) bandwidth is used or the Network Bandwidth Calculations for a normally loaded network show that more than 30% of the 78 kbps bandwidth is used.

(2) the Government has approved the Network Bandwidth Calculations submittal.

b. The backbone shall be a TP/FT-10 network otherwise.

1.12.2 Control Network Requirements

The control network shall meet the following requirements:

a. The backbone shall have no control devices connected to it. Only CEA-709.1B Routers and CEA-709.1B TP/FT-10 to IP Routers may be connected to the backbone. CEA-709.1B TP/FT-10 to IP Routers are specified in Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEMS

b. The backbone shall be installed such that a router at the Building Point of Connection (BPOC) location as shown may be connected to the backbone.

c. The local control bus shall use CEA-709.1B over a TP/FT-10 network in doubly-terminated bus topology in accordance with CEA-709.3

d. The local control busses shall be installed such that no node (device connected to the control network) has more than two CEA-709.1B Routers and CEA-709.3 Repeaters (in any combination) between it and the backbone, including the router connected to the backbone.

e. All DDC Hardware shall connect to a local control bus.

f. All DDC Hardware shall be locally powered; link power is not acceptable.

PART 2 PRODUCTS

PART 2 of this specification covers requirements for Products (equipment). Installation requirements for these products are covered in PART 3 of this specification.

2.1 EQUIPMENT

2.1.1 General Requirements

Units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of these and similar products. The standard products shall have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two year use shall include applications of equipment and materials under similar circumstances and of similar size. DDC Hardware not meeting the two-year field service requirement shall be acceptable provided it has been successfully used by the Contractor in a minimum of two previous projects. The equipment items shall be supported by a service organization. Items of the same type and purpose shall be identical, including equipment, assemblies, parts and components. Manufacturer's catalog data sheets documenting compliance with product specifications shall be submitted as specified for each product installed under this specification.

2.1.2 Operation Environment Requirements

All products shall be rated for continuous operation under the following conditions:

a. Pressure: Pressure conditions normally encountered in the installed location.

b. Vibration: Vibration conditions normally encountered in the installed location.

c. Temperature:

(1) Products installed indoors: Ambient temperatures in the range of 32 to 112 degrees F and temperature conditions outside this range normally encountered at the installed location.

(2) Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of -35 to plus 151 degrees F and temperature conditions outside this range normally encountered at the installed location.

d. Humidity: 10% to 95% relative humidity, noncondensing and humidity conditions outside this range normally encountered at the installed location.

2.2 ENCLOSURES AND WEATHERSHIELDS

2.2.1 Enclosures

Enclosures shall meet the following minimum requirements:

a. Outdoors: Enclosures located outdoors shall meet NEMA 250 Type 4 requirements.

b. Mechanical and Electrical Rooms: Enclosures located in mechanical or electrical rooms shall meet NEMA 250 Type 2 or Type 4 requirements.

c. Other Locations: Enclosures in other locations including but not limited to occupied spaces, above ceilings, and plenum returns shall meet NEMA 250 Type 1 requirements.

Enclosures supplied as an integral (pre-packaged) part of another product are acceptable.

2.2.2 Weathershields

Weathershields for sensors located outdoors shall prevent the sun from directly striking the sensor. The weathershield shall be provided with adequate ventilation so that the sensing element responds to the ambient conditions of the surroundings. The weathershield shall prevent rain from directly striking or dripping onto the sensor. Weathershields installed near outside air intake ducts shall be installed such that normal outside air flow does not cause rainwater to strike the sensor. Weathershields shall be constructed of galvanized steel painted white, unpainted aluminum, aluminum painted white, or white PVC.

2.3 TUBING

2.3.1 Copper

Copper tubing shall conform to ASTM B 88 and ASTM B 88M

2.3.2 Stainless Steel

Stainless steel tubing shall conform to ASTM A 269

2.3.3 Plastic

Plastic tubing shall have the burning characteristics of linear low-density polyethylene tubing, shall be self-extinguishing when tested in accordance with ASTM D 635, shall have UL 94 V-2 flammability classification or better, and shall withstand stress cracking when tested in accordance with ASTM D 1693. Plastic-tubing bundles shall be provided with Mylar barrier and flame-retardant polyethylene jacket.

2.4 NETWORK HARDWARE

2.4.1 CEA-709.1B Network Hardware

2.4.1.1 CEA-709.1B Routers

CEA-709.1B Routers (including routers configured as repeaters) shall meet the requirements of CEA-709.1B and shall provide connection between two or more CEA-709.3 TP/FT-10 channels.

2.4.1.2 CEA-709.3 Repeaters

CEA-709.3 Repeaters shall be physical layer repeaters in accordance with CEA-709.3.

2.4.2 Gateways

Gateways shall perform bi-directional protocol translation from one non-CEA-709.1B protocol to CEA-709.1B. Gateways shall incorporate exactly two network connections: one shall be for connection to a TP/FT-10 network in accordance with CEA-709.3 and the second shall be as required to communicate with the non-CEA-709.1B network.

2.5 WIRE AND CABLE

All wire and cable shall meet the requirements of NFPA 70 and NFPA 90A in addition to the requirements of this specification.

2.5.1 Terminal Blocks

Terminal blocks which are not integral to other equipment shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

2.5.2 Control Wiring for Binary Signals

Control wiring for binary signals shall be 18 AWG copper and shall be rated for 300-volt service.

2.5.3 Wiring for 120-Volt Circuits

Wiring for 120-volt circuits shall be 18 AWG or thicker stranded copper and shall be rated for 600-volt service.

2.5.4 Control Wiring for Analog Signals

Control Wiring for Analog Signals shall be 18 AWG, copper, single- or multiple-twisted, minimum 2 inch lay of twist, 100% shielded pairs, and shall have a 300-volt insulation. Each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.5.5 Transformers

Transformers shall be UL 1585 approved. Transformers shall be sized so that the connected load is no greater than 80% of the transformer rated capacity.

2.6 AUTOMATIC CONTROL VALVES

Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Valve bodies shall meet ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150% of the system design operating pressure.

Unless otherwise specified or shown, valve leakage shall meet FCI 70-2 Class IV leakage rating (0.01% of valve Kv). Unless otherwise specified or shown, valves shall have globe-style bodies. Unless otherwise specified:

a. bodies for valves 1.5 inches and smaller shall be brass or bronze, with threaded or union ends

b. bodies for 2 inch valves shall have threaded ends

c. bodies for valves 2 to 3 inches shall be of brass, bronze or iron.

d. bodies for valves 2.5 inches and larger shall be provided with flanged-end connections.

e. for modulating applications, valve Kv (Cv) shall be within 100 to 125% of the Kv (Cv) shown.

f. for two position applications (where the two positions are full open and full closed) the Kv (Cv) shall be the largest available for the valve size.

f. valve and actuator combination shall be normally open or normally closed as shown.

2.6.1 Ball Valves

Balls shall be stainless steel or nickel plated brass. Valves shall have blow-out proof stems. In steam and high temperature hot water applications, the valve-to-actuator linkage shall provide a thermal break.

2.6.2 Butterfly Valves

Butterfly valves shall be threaded lug type suitable for dead-end service and modulation to the fully-closed position, with carbon-steel bodies and non-corrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from -20 to plus 250 degrees F. The rated Kv (Cv) for butterfly valves shall be the value Kv (Cv) at 70% (60 degrees) open position. Valve leakage shall meet FCI 70-2 Class VI leakage rating.

2.6.3 Two-Way Valves

Two-way modulating valves used for liquids shall have an equal-percentage characteristic. Two-way modulating valves used for steam shall have a linear characteristic.

2.6.4 Three-Way Valves

Three-way modulating valves shall provide equal percentage flow control with constant total flow throughout full plug travel.

2.6.5 Duct-Coil and Terminal-Unit-Coil Valves

Control valves with either flare-type or solder-type ends shall be provided for duct or terminal-unit coils. Flare nuts shall be provided for each flare-type end valve.

2.6.6 Valves for Chilled-Water, Condenser-Water, and Glycol Service

Valve internal trim shall be Type 316 stainless steel. Valves 4 inches and

larger shall be butterfly valves.

2.6.7 Valves for High-Temperature Water, Hot-Water and Dual Temperature Service

a. Valves for hot water service between 210 and 250 degrees F and dual-temperature service shall have internal trim (including seats, seat rings, modulating plugs, and springs) of Type 316 stainless steel. Internal trim for valves controlling water below 210 degrees F shall be brass, bronze or Type 316 stainless steel. Nonmetallic valve parts shall be suitable for a minimum continuous operating temperature of 250 or 50 degrees F above the system design temperature, whichever is higher. Valves 4 inches and larger shall be butterfly valves.

2.7 DAMPERS

2.7.1 Damper Assembly

A single damper section shall have blades no longer than 48 inch and shall be no higher than 72 inch. Maximum damper blade width shall be 8 inch. Larger sizes shall be made from a combination of sections. Dampers shall be steel, or other materials where shown. Flat blades shall be made rigid by folding the edges. Blade-operating linkages shall be within the frame so that blade-connecting devices within the same damper section shall not be located directly in the air stream. Damper axles shall be 1/2 inch minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings. Pressure drop through dampers shall not exceed 0.04 inches water gauge at 1,000 ft/min in the wide-open position. Frames shall not be less than 2 inch in width. Dampers shall be tested in accordance with AMCA 500-D.

2.7.2 Operating Linkages

Operating links external to dampers, such as crank arms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, shall withstand a load equal to at least 300% of the maximum required damper-operating force. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crank arms shall control the open and closed positions of dampers.

2.7.3 Damper Types

2.7.3.1 Flow Control Dampers

Outside air, return air, relief air, exhaust, face and bypass dampers shall be provided where shown and shall be parallel-blade or opposed blade type as shown on the Damper Schedule. Blades shall have interlocking edges and shall be provided with compressible seals at points of contact. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Unless otherwise shown, dampers shall be AMCA 500-D Class 2 and shall not leak in excess of 20 cfm per square foot at 4 inches water gauge static pressure when closed. Outside air damper seals shall be suitable for an operating temperature range of -40 to plus 167 degrees F. Dampers shall be rated at not less than 2000 ft/min air velocity.

2.7.3.2 Mechanical Rooms and Other Utility Space Ventilation Dampers

Utility space ventilation dampers shall be as shown. Unless otherwise shown, dampers shall be AMCA 500-D class 4 and shall not leak in excess of 80 cfm per square foot at 4 inches water gauge static pressure when closed. Dampers shall be rated at not less than 1500 ft/min air velocity.

2.7.3.3 Smoke Dampers

Smoke-damper and actuator assembly shall meet the current requirements of NFPA 90A, UL 555, and UL 555S. Combination fire and smoke dampers shall be rated for 250 degrees F Class II leakage per UL 555S.

2.8 SENSORS AND INSTRUMENTATION

Unless otherwise specified, sensors and instrumentation shall incorporate an integral transmitter or be provided with a transmitter co-located with the sensor. Sensors and instrumentation, including their transmitters, shall meet the specified accuracy and drift requirements at the input of the connected DDC Hardware's analog-to-digital conversion. Sensors and instrumentation, including their transmitters, shall meet or exceed the specified range.

2.8.1 Transmitters

The transmitter shall match the characteristics of the sensor. Transmitters providing analog values shall produce a linear 4-20 mAdc, 0-10 Vdc or SNVT output corresponding to the required operating range and shall have zero and span adjustment. Transmitters providing binary values shall have dry contacts or SNVT output. Transmitters with SNVT output are Application Specific Controllers (ASCs) and shall meet all ASC requirements. (note: ASCs are specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE)

2.8.2 Temperature Sensors

2.8.2.1 Sensor Ranges and Accuracy

Temperature sensors may be provided without transmitters. Temperature sensors, including transmitter if used, shall have minimum operating ranges, minimum accuracy and maximum drift as specified below for the application:

a. Conditioned Space Temperature

(1) Operating Range: 50 to 86 degrees F.

(2) Accuracy: +/- 1 degree F over the operating range.

(3) Drift: Maximum 1 degree F per year.

b. Unconditioned Space Temperature

(1) Operating Range: 20 to 150 degrees F.

(2) Accuracy: +/- 1 degree F over the range of 30 to 131 degrees F and +/- 4 degrees F over the rest of the operating range.

(3) Drift: Maximum 1 degree F per year.

c. Duct Temperature

(1) Operating Range: 40 to 140 degrees F.

(2) Accuracy: +/- 2 degrees F.

(3) Drift: Maximum 2 degrees F per year.

d. Outside Air Temperature

(1) Operating Range: -1 to 130 degrees F.

(2) Accuracy:

(a) +/- 2 degrees F over the range of -30 to plus 130 degrees F.

(b) +/- 1 degreeF over the range of 30 to 100 degrees F.

(3) Drift: Maximum 1 degree F per year.

e. High Temperature Hot Water

(1) Operating Range: 150 to 450 degrees F.

(2) Accuracy: +/- 3.6 degrees F.

(3) Drift: Maximum +/- 2 degrees F per year.

f. Chilled Water

(1) Operating Range: 30 to 100 degrees F.

(2) Accuracy: +/- 0.8 degrees F over the range of 35 to 65 degrees F and +/- 2 degrees F over the rest of the operating range.

(3) Drift: Maximum 0.8 degrees F per year.

g. Heating Hot Water

(1) Operating Range: 70 to 250 degrees F.

(2) Accuracy: +/- 2 degrees F.

(3) Drift: Maximum 2 degrees F per year.

h. Condenser Water

(1) Operating Range: 30 to 130 degrees F.

(2) Accuracy: +/- 1 degree F.

(3) Drift: Maximum 1 degree F per year.

2.8.2.2 Point Temperature Sensors

Point Sensors shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper.

2.8.2.3 Averaging Temperature Sensors

Averaging sensors shall be a continuous element with a minimum length equal to 1 foot/square foot of duct cross-sectional area at the installed location. The sensing element shall have a bendable copper sheath.

2.8.2.4 Thermowells

Thermowells shall be Series 300 stainless steel with threaded brass plug and chain, 2 inch lagging neck and extension type well. Inside diameter and insertion length shall be as required for the application.

2.8.3 Relative Humidity Sensor

Relative humidity sensors shall use bulk polymer resistive or thin film capacitive type non-saturating sensing elements capable of withstanding a saturated condition without permanently affecting calibration or sustaining damage. The sensors shall include removable protective membrane filters. Where required for exterior installation, sensors shall be capable of surviving below freezing temperatures and direct contact with moisture without affecting sensor calibration. When used indoors, the sensor shall be capable of being exposed to a condensing air stream (100% RH) with no adverse effect to the sensor's calibration or other harm to the instrument. The sensor shall be of the wall-mounted or duct-mounted type, as required by the application, and shall be provided with any required accessories. Sensors used in duct high-limit applications shall have a bulk polymer resistive sensing element. Duct-mounted sensors shall be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. Relative humidity (RH) sensors shall measure relative humidity over a range of 0% to 100% with an accuracy of +/- 3%. RH sensors shall function over a temperature range of 25 to 130 degrees F and shall not drift more than 2% per year.

2.8.4 Carbon Dioxide (CO2) Sensors

Carbon dioxide (CO2) sensors shall measure CO2 concentrations between 0 to 2000 parts per million (ppm) using non-dispersive infrared (NDIR) technology with an accuracy of +/- 75 ppm and a maximum response time of 1 minute. The sensor shall be rated for operation at ambient air temperatures within the range of 32 to 122 degrees F and relative humidity within the range of 0 to 95% (non-condensing). The sensor shall have a maximum drift of 2%. The sensor chamber shall be manufactured with a non-corrosive material (such as gold-plating) that does not affect carbon dioxide sample concentration. Duct mounted sensors shall be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage.

2.8.5 Differential Pressure Instrumentation

2.8.5.1 Differential Pressure Sensors

Differential Pressure Sensor range shall be as shown or as required for the application. Pressure sensor ranges shall not exceed the high end range shown on the Points Schedule by more than 50%. The over pressure rating shall be a minimum of 150% of the highest design pressure of either input to the sensor. The accuracy shall be +/- 2% of full scale.

2.8.5.2 Differential Pressure Switch

The switch shall have a user-adjustable setpoint. The setpoint shall not be in the upper or lower quarters of the range. The over pressure rating shall be a minimum of 150% of the highest design pressure of either input to the sensor. The switch shall have two sets of contacts and each contact shall have a rating greater than it's connected load. Contacts shall open or close upon rise of pressure above the setpoint or drop of pressure below the setpoint as shown.

2.8.6 Flow Sensors

2.8.6.1 Airflow Measurement Array (AFMA)

a. Airflow Straightener.-AFMAs shall contain an airflow straightener if required by the AFMA manufacturer's published installation instructions. The straightener shall be contained inside a flanged sheet metal casing, with the AMFA located as specified according to the published recommendation of the AFMA manufacturer. In the absence of published documentation airflow straighteners shall be provided if there is any duct obstruction within 5 duct diameters upstream of the AFMA. Air-flow straighteners, where required, shall be constructed of 0.125 inch aluminum honeycomb and the depth of the straightener shall not be less than 1.5 inches.

b. Resistance to airflow.-The resistance to air flow through the AFMA, including the airflow straightener shall not exceed 0.08 inch water gauge at an airflow of 2,000 fpm. AFMA construction shall be suitable for operation at airflows of up to 5,000 fpm over a temperature range of 40 to 120 degrees F.

c. Outside air temperature.-In outside air measurement or in low-temperature air delivery applications, the AFMA shall be certified by the manufacturer to be accurate as specified over a temperature range of -20 to plus 120 degrees F.

d. Pitot Tube AFMA.-Each Pitot Tube AFMA shall contain an array of velocity sensing elements. The velocity sensing elements shall be of the multiple pitot tube type with averaging manifolds. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published installation instructions of the AFMA manufacturer. Pitot Tube AFMAs shall have an accuracy of +/- 3% over a range of 500 to 2,500 fpm.

e. Electronic AFMA.-Each electronic AFMA shall consist of an array of velocity sensing elements of the resistance temperature detector (RTD) or thermistor type. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published application data of the AFMA manufacturer. Electronic AFMAs shall have an accuracy of +/- 3% percent over a range of 125 to 2,500 fpm and the output shall be temperature compensated over a range of 32 to 212 degrees F.

2.8.6.2 Orifice Plate

Orifice plate shall be made of an austenitic stainless steel sheet of 0.125 inch nominal thickness with an accuracy of +/- 1% of full flow. The orifice plate shall be flat within 0.002 inches. The orifice surface roughness shall not exceed 20 micro-inches. The thickness of the

cylindrical face of the orifice shall not exceed 2% of the pipe inside diameter or 12.5% of the orifice diameter, whichever is smaller. The upstream edge of the orifice shall be square and sharp. Where orifice plates are used, concentric orifice plates shall be used in all applications except steam flow measurement in horizontal pipelines.

2.8.6.3 Flow Nozzle

Flow nozzle shall be made of austenitic stainless steel with an accuracy of +/- 1% of full flow. The inlet nozzle form shall be elliptical and the nozzle throat shall be the quadrant of an ellipse. The thickness of the nozzle wall and flange shall be such that distortion of the nozzle throat from strains caused by the pipeline temperature and pressure, flange bolting, or other methods of installing the nozzle in the pipeline shall not cause the accuracy to degrade beyond the specified limit. The outside diameter of the nozzle flange or the design of the flange facing shall be such that the nozzle throat shall be centered accurately in the pipe.

2.8.6.4 Venturi Tube

Venturi tube shall be made of cast iron or cast steel and shall have an accuracy of +/- 1% of full flow. The throat section shall be lined with austenitic stainless steel. Thermal expansion characteristics of the lining shall be the same as that of the throat casting material. The surface of the throat lining shall be machined to a +/- 50 micro inch finish, including the short curvature leading from the converging entrance section into the throat.

2.8.6.5 Annular Pitot Tube

Annular pitot tube shall be made of austenitic stainless steel with an accuracy of +/- 2% of full flow and a repeatability of +/- 0.5% of measured value. The unit shall have at least one static port and no less than four total head pressure ports with an averaging manifold.

2.8.6.6 Insertion Turbine Flowmeter

Insertion Turbine Flowmeter accuracy shall be +/- 1% of reading for a minimum turndown ratio of 1:1 through a maximum turndown ratio of 50:1. Repeatability shall be +/- 0.25% of reading. The meter flow sensing element shall operate over a range suitable for the installed location with a pressure loss limited to 1% of operating pressure at maximum flow rate. Design of the flowmeter probe assembly shall incorporate integral flow, temperature, and pressure sensors. The turbine rotor assembly shall be constructed of Series 300 stainless steel and use Teflon seals.

2.8.6.7 Vortex Shedding Flowmeter

Vortex Shedding Flowmeter accuracy shall be within +/- 0.8% of the actual flow. The flow meter body shall be made of austenitic stainless steel. The vortex shedding flowmeter body shall not require removal from the piping in order to replace the shedding sensor.

2.8.6.8 Positive Displacement Flow Meter

The flow meter shall be a direct reading, gerotor, nutating disk or vane type displacement device rated for liquid service as shown. A counter shall be mounted on top of the meter, and shall consist of a non-resettable mechanical totalizer for local reading, and a pulse transmitter for remote

reading. The totalizer shall have a six digit register to indicate the volume passed through the meter in gallons, and a sweep-hand dial to indicate down to 0.25 gallons. The pulse transmitter shall have a hermetically sealed reed switch which is activated by magnets fixed on gears of the counter. The meter shall have a bronze body with threaded or flanged connections as required for the application. Output accuracy shall be +/- 2% of the flow range. The maximum pressure drop at full flow shall be 5 psig.

2.8.6.9 Flow Meters, Paddle Type

Sensor shall be non-magnetic, with forward curved impeller blades designed for water containing debris. Sensor accuracy shall be +/- 2% of rate of flow, minimum operating flow velocity shall be 1 foot per second. Sensor repeatability and linearity shall be +/- 1%. Materials which will be wetted shall be made from non-corrosive materials and shall not contaminate water. The sensor shall be rated for installation in pipes of 3 to 40 inch diameters. The transmitter housing shall be a NEMA 250 Type 4 enclosure.

2.8.6.10 Flow Switch

Flow switch shall have a repetitive accuracy of +/- 10% of actual flow setting. Switch actuation shall be adjustable over the operating flow range. The switch shall have Form C snap-action contacts, rated for the application. The flow switch shall have non flexible paddle with magnetically actuated contacts and be rated for service at a pressure greater than the installed conditions. Flow switch for use in sewage system shall be rated for use in corrosive environments encountered.

2.8.6.11 Gas Utility Flow Meter

Gas utility flow meter shall be diaphragm or bellows type (gas positive displacement meters) for flows up to 2500 SCFH and axial flow turbine type for flows above 2500 SCFH, designed specifically for natural gas supply metering, and rated for the pressure, temperature, and flow rates of the installation. Meter shall have a minimum turndown ratio of 10 to 1 with an accuracy of +/- 1% of actual flow rate. The meter index shall include a direct reading mechanical totalizing register and electrical impulse dry contact output for remote monitoring. For gas flows of less than 1500 cubic-feet/second, the electrical impulse dry contact output shall provide not less than 1 pulse per 100 cubic feet of gas and shall not exceed 15 pulses per second for the installed application. For gas flows 1500 cubic-feet/second or greater, the pulse rate shall not be the greatest pulse-rate available but not to exceed 15 pulses per second for the installed application. The electrical impulse dry contact output shall not require field adjustment or calibration.

2.8.7 Electrical Instruments

Electrical Instruments shall have an input range as shown or sized for the application. Unless otherwise specified, AC instrumentation shall be suitable for 60 Hz operation.

2.8.7.1 Watt or Watthour Transducers

Watt transducers shall measure voltage and current and shall output kW, kWh, or kW and kWh as shown. kW outputs shall have an accuracy of +/- 0.25% over a power factor range of 0.1 to 1. kWh outputs shall be a pulse output and shall have an accuracy of +/- 0.5% over a power factor range of

0.1 to 1.

2.8.7.2 Current Transducers

Current transducers shall accept an AC current input and shall have an accuracy of +/- 2% of full scale. An integral power supply shall be provided if required for the analog output signal. The device shall have a means for calibration.

2.8.7.3 Current Sensing Relays (CSRs)

Current sensing relays (CSRs) shall provide a normally-open contact with a voltage and amperage rating greater than its connected load. Current sensing relays shall be of split-core design. The CSR shall be rated for operation at 200% of the connected load. Voltage isolation shall be a minimum of 600 volts. The CSR shall auto-calibrate to the connected load.

2.8.7.4 Voltage Transducers

Voltage transducers shall accept an AC voltage input and have an accuracy of +/- 0.25% of full scale. An integral power supply shall be provided if required for the analog output signal. The device shall have a means for calibration. Line side fuses for transducer protection shall be provided.

2.8.8 pH Sensor

The sensor shall be suitable for applications and chemicals encountered in water treatment systems of boilers, chillers and condenser water systems. Construction, wiring, fittings and accessories shall be corrosion and chemical resistant with fittings for tank or suspension installation. Housing shall be polyvinylidene fluoride with O-rings made of chemical resistant materials which do not corrode or deteriorate with extended exposure to chemicals. The sensor shall be encapsulated. Periodic replacement shall not be required for continued sensor operation. Sensors shall use a ceramic junction and pH sensitive glass membrane capable of withstanding a pressure of 100 psig at 150 degrees F. The reference cell shall be double junction configuration. Sensor range shall be 0 to 12 pH, stability 0.05, sensitivity 0.02, and repeatability of +/- 0.05 pH value, response of 90% of full scale in one second and a linearity of 99% of theoretical electrode output measured at 76 degrees F.

2.8.9 Oxygen Analyzer

Oxygen analyzer shall consist of a zirconium oxide sensor for continuous sampling and an air-powered aspirator to draw flue gas samples. The analyzer shall be equipped with filters to remove flue air particles. Sensor probe temperature rating shall be 815 degrees F. The sensor assembly shall be equipped for flue flange mounting.

2.8.10 Carbon Monoxide Analyzer

Carbon monoxide analyzer shall consist of an infrared light source in a weather proof steel enclosure for duct or stack mounting. An optical detector/analyzer in a similar enclosure, suitable for duct or stack mounting shall be provided. Both assemblies shall include internal blower systems to keep optical windows free of dust and ash at all times. The third component of the analyzer shall be the electronics cabinet. Automatic flue gas temperature compensation and manual/automatic zeroing devices shall be provided. Unit shall read parts per million (ppm) of

carbon monoxide in the range of 100 to 1500 ppm and the response time shall be less than 3 seconds to 90% value. Unit measurement range shall not exceed specified range by more that 50%. Repeatability shall be +/- 2% of full scale with an accuracy of +/- 3% of full scale.

2.8.11 Occupancy Sensors

Occupancy sensors shall have occupancy-sensing sensitivity adjustment and an adjustable off-delay timer with a range encompassing 30 seconds to 15 minutes. Occupancy sensors shall be rated for operation in ambient air temperatures ranging from 50 to 104 degrees F or temperatures normally encountered in the installed location. Sensors integral to wall mount on-off light switches shall have an auto-off switch. Wall switch sensors shall be decorator style and shall fit behind a standard decorator type wall plate. All occupancy sensors, power packs, and slave packs shall be UL listed. In addition to any outputs required for lighting control, the occupancy sensor shall provide a contact output rated at 1A at 24 Vac or a SNVT output.

2.8.11.1 Passive Infrared (PIR) Occupancy Sensors

PIR occupancy sensors shall have a multi-level, multi-segmented viewing lens and a conical field of view with a viewing angle of 180 degrees and a detection of at least 20 feet unless otherwise shown or specified. PIR Sensors shall provide field-adjustable background light-level adjustment with an adjustment range suitable to the light level in the sensed area, room or space. PIR sensors shall be immune to false triggering from RFI and EMI.

2.8.11.2 Ultrasonic Occupancy Sensors

Ultrasonic sensors shall operate at a minimum frequency 32 kHz and shall be designed to not interfere with hearing aids.

2.8.11.3 Dual-Technology Occupancy Sensor (PIR and Ultrasonic)

Dual-Technology Occupancy Sensors shall meet the requirements of both PIR and Ultrasonic Occupancy Sensors.

2.8.12 Vibration Switch

Vibration switch shall be solid state, enclosed in a NEMA 250 Type 4 or Type 4X housing with sealed wire entry. Unit shall have two independent sets of Form C switch contacts with one set to shutdown equipment upon excessive vibration and a second set for monitoring alarm level vibration. The vibration sensing range shall be a true rms reading, suitable for the application. The unit shall include either displacement response for low speed or velocity response for high speed application. The frequency range shall be at least 2 Hz to 200 Hz. Contact time delay shall be 3 seconds. The unit shall have independent start-up and running delay on each switch contact. Alarm limits shall be adjustable and setpoint accuracy shall be +/- 10% of setting with repeatability of plus or minus 2%.

2.8.13 Conductivity Sensor

Sensor shall include local indicating meter and shall be suitable for measurement of conductivity of water in boilers, chilled water systems, condenser water systems, distillation systems, or potable water systems as shown. Sensor shall sense from 0 to 10 microSeimens per centimeter (uS/cm)

for distillation systems, 0 to 100 uS/cm for boiler, chilled water, and potable water systems and 0 to 1000 uS/cm for condenser water systems. Contractor shall field verify the ranges for particular applications and adjust the range as required. Contractor shall submit a complete water quality analysis of a sample of the process to be monitored with the submittal of the sensor manufacturer's catalog data. The output shall be temperature compensated over a range of 32 to 212 degrees F. The accuracy shall be +/- 2% of the full scale reading. Sensor shall have automatic zeroing and shall require no periodic maintenance or recalibration.

2.8.14 NOx Monitor

Monitor shall continuously monitor and give local indication of boiler stack gas for NOx content. It shall be a complete system designed to verify compliance with the Clean Air Act standards for NOx normalized to a 3% oxygen basis and shall have a range of from 0 to 100 ppm. Sensor shall be accurate to +/- 5 ppm. Sensor shall output NOx and oxygen levels and binary output that changes state when the NOx level is above a locally adjustable NOx setpoint. Sensor shall have normal, trouble and alarm lights. Sensor shall have heat traced lines if the stack pickup is remote from the sensor. Sensor shall be complete with automatic zero and span calibration using a timed calibration gas system, and shall not require periodic maintenance or recalibration.

2.8.15 Turbidity Sensor

Sensor shall include a local indicating meter and shall be suitable for measurement of turbidity of water. Sensor shall sense from 0 to 1000 Nephelometric Turbidity Units (NTU). Range shall be field-verified for the particular application and adjusted as required. The output shall be temperature compensated over a range of 0 to 212 degrees F. The accuracy shall be +/- 5% of full scale reading. Sensor shall have automatic zeroing and shall not require periodic maintenance or recalibration.

2.8.16 Chlorine Detector

The detector shall measure concentrations of chlorine in water in the range 0 to 20 ppm with a repeatability of +/- 1% of full scale and an accuracy of +/- 2% of full scale. The Chlorine Detector transmitter shall be housed in a non-corrosive NEMA 250 Type 4X enclosure. Detector shall include a local panel with adjustable alarm trip level, local audio and visual alarm with silence function.

2.8.17 Floor Mounted Leak Detector

Leak detectors shall use electrodes mounted at slab level with a minimum built-in-vertical adjustment of 0.125 inches. Detector shall have a binary output. The indicator shall be manual reset type.

2.8.18 Temperature Switch

2.8.18.1 Duct Mount Temperature Low Limit Safety Switch (Freezestat)

Duct mount temperature low limit switches (Freezestats) shall be manual reset, low temperature safety switches with a minimum element length of 1 foot/square-foot of coverage which shall respond to the coldest 18 inch segment with an accuracy of +/- 3.6 degrees F. The switch shall have a field-adjustable setpoint with a range of at least 30 to 50 degrees F. The switch shall have two sets of contacts, and each contact shall have a

rating greater than its connected load. Contacts shall open or close upon drop of temperature below setpoint as shown and shall remain in this state until reset.

2.8.18.2 Pipe Mount Temperature Limit Switch (Aquastat)

Pipe mount temperature limit switches (aquastats) shall have a field adjustable setpoint between 60 and 90 degrees F, an accuracy of +/- 3.6 degrees F and a 10 degrees F fixed deadband. The switch shall have two sets of contacts, and each contact shall have a rating greater than its connected load. Contacts shall open or close upon change of temperature above or below setpoint as shown.

2.8.19 Damper End Switches

Each end switch shall be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure shall be suitable for mounting on the duct exterior and shall permit setting the position of the trip lever that actuates the switch. The trip lever shall be aligned with the damper blade.

2.9 INDICATING DEVICES

All indicating devices shall display readings in English (inch-pound) units.

2.9.1 Thermometers

Thermometers shall not contain mercury. Unless otherwise specified, thermometers shall have an accuracy of +/- 3% of scale range. Thermometers shall have a range suitable for the application with an upper end of the range not to exceed 150% of the design upper limit.

2.9.1.1 Piping System Thermometers

Piping system thermometers shall have brass, malleable iron or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 9 inch scale. Piping system thermometers shall have an accuracy of +/- 1% of scale range. Thermometers for piping systems shall have rigid stems with straight, angular, or inclined pattern. Thermometer stems shall have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem shall be filled with a heat-transfer medium.

2.9.1.2 Air-Duct Thermometers

Air-duct thermometers shall have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

2.9.2 Pressure Gauges

Gauges shall be suitable for field or panel mounting as required, shall have black legend on white background, and shall have a pointer traveling through a 270-degree arc. Gauge range shall be suitable for the application with an upper end of the range not to exceed 150% of the design upper limit. Accuracy shall be +/- 3% of scale range. Gauges shall meet requirements of ASME B40.100.

2.9.3 Low Differential Pressure Gauges

Gauges for low differential pressure measurements shall be a minimum of 3.5 inch (nominal) size with two sets of pressure taps, and shall have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauge range shall be suitable for the application with an upper end of the range not to exceed 150% of the design upper limit. Accuracy shall be plus or minus two percent of scale range.

2.10 OUTPUT DEVICES

Output Devices with SNVT input are ASCs and shall meet all ASC requirements in addition to the output device requirements. (Note: ASCs are specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE.)

2.10.1 Actuators

Actuators shall be electric (electronic). All actuators shall be normally open (NO), normally closed (NC) or fail-in-last-position (FILP) as shown. Normally open and normally closed actuators shall be of mechanical spring return type. Electric actuators shall have an electronic cut off or other means to provide burnout protection if stalled. Actuators shall have a visible position indicator. Electric actuators shall provide position feedback to the controller as shown. Actuators shall smoothly open or close the devices to which they are applied. Electric actuators shall have a full stroke response time in both directions of 90 seconds or less at rated load. Electric actuators shall be of the foot-mounted type with an oil-immersed gear train or the direct-coupled type. Where multiple electric actuators operate from a common signal, the actuators shall provide an output signal identical to its input signal to the additional devices.

2.10.1.1 Valve Actuators

Valve actuators shall provide shutoff pressures and torques as shown on the Valve Schedule.

2.10.1.2 Damper Actuators

Damper actuators shall provide the torque necessary per damper manufacturer's instructions to modulate the dampers smoothly over its full range of operation and torque shall be at least 6 inch-pounds/1 square foot of damper area for opposed blade dampers and 9 inch-pounds/1 square foot of damper area for parallel blade dampers.

2.10.1.3 Positive Positioners

Positive positioners shall be a pneumatic relay with a mechanical position feedback mechanism and an adjustable operating range and starting point.

2.10.2 Relays

Control relay contacts shall have utilization category and ratings selected for the application, with a minimum of two sets of contacts enclosed in a dust proof enclosure. Each set of contacts shall incorporate a normally open (NO), normally closed (NC) and common contact. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage.

2.11 USER INPUT DEVICES

User Input Devices, including potentiometers, switches and momentary contact push-buttons with SNVT output are Application Specific Controllers (ASCs) and shall meet all ASC requirements. (Note: ASCs are specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE). Potentiometers shall be of the thumb wheel or sliding bar type. Momentary Contact Push-Buttons may include an adjustable timer for their output. User input devices shall be labeled for their function.

2.12 MULTIFUNCTION DEVICES

Multifunction devices are products which combine the functions of multiple sensor, user input or output devices into a single product. Unless otherwise specified, the multifunction device shall meet all requirements of each component device. Where the requirements for the component devices conflict, the multifunction device shall meet the most stringent of the requirements.

2.12.1 Current Sensing Relay Command Switch

The Current Sensing Relay portion shall meet all requirements of the Current Sensing Relay input device. The Command Switch portion shall meet all requirements of the Relay output device except that it shall have at least one normally-open (NO) contact.

2.12.2 Thermostats

Thermostats shall be multifunction devices incorporating a temperature sensor and a temperature indicating device. Thermostats shall not contain mercury (Hg). In addition, the thermostat shall have the following as specified and shown:

a. A User Input Device which shall adjust a temperature setpoint output.

b. A User Input Momentary Contact Button and an output indicating zone occupancy.

c. A three position User Input Switch labeled to indicate heating, cooling and off positions ('HEAT-COOL-OFF' switch) and providing corresponding outputs.

d. A two position User Input Switch labeled with 'AUTO' and 'ON' positions and providing corresponding outputs.

e. A multi-position User Input Switch with 'OFF' and at least two fan speed positions and providing corresponding outputs.

2.13 DIRECT DIGITAL CONTROL (DDC) HARDWARE

2.13.1 General Requirements

All DDC Hardware shall meet the following requirements:

a. It shall incorporate a "service pin" which, when pressed will cause the DDC Hardware to broadcast its 48-bit NodeID and its ProgramID over the network. The service pin shall be distinguishable and accessible.

b. It shall incorporate a light to indicate the device is receiving power.

c. It shall incorporate a TP/FT-10 transceiver in accordance with CEA-709.3 and connections for TP/FT-10 control network wiring. It shall not have connections to any other network media type.

d. It shall communicate on the network using only the CEA-709.1B protocol.

e. It shall be locally powered; link powered devices are not acceptable.

f. LonMark external interface files (XIF files), as defined in the LonMark XIF Guide, shall be submitted for each type of DDC Hardware.

g. Application programs and configuration settings shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration settings.

h. It shall have all functionality specified and required to support the application (Sequence of Operation or portion thereof) in which it is used, including but not limited to:

(1) It shall provide input and output SNVTs as specified and required to support the sequence and application in which it is used.

(2) It shall be configurable via standard or user-defined configuration parameters (SCPT or UCPT), SNVT network configuration inputs (*nci*), or hardware settings on the controller itself as specified and as required to support the sequence and application in which it is used.

i. It shall meet 47 CFR 15 requirements and have UL 916 or equivalent safety listing.

2.13.2 Hardware Input-Output (I/O) Functions

DDC Hardware incorporating hardware input-output (I/O) functions shall meet the following requirements:

a. Analog Inputs: DDC Hardware analog inputs (AIs) shall perform analog to digital (A-to-D) conversion with a minimum resolution of 8 bits plus sign or better as needed to meet the accuracy requirements specified in paragraph INPUT MEASUREMENT ACCURACY. Signal conditioning including transient rejection shall be provided for each analog input. Analog inputs shall be capable of being individually calibrated for zero and span. The AI shall incorporate common mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10,000 ohms.

b. Analog Outputs: DDC Hardware analog outputs (AOs) shall perform digital to analog (D-to-A) conversion with a minimum resolution of 8 bits plus sign, and output a signal with a range of 4-20 mAdc or 0-10 Vdc. Analog outputs shall be capable of being individually calibrated for zero and span.

c. Binary Inputs: DDC Hardware binary inputs (BIs) shall accept contact closures and shall ignore transients of less than 5 milli-second duration. Isolation and protection against an applied steady-state voltage up to 180 Vac peak shall be provided.

d. Binary Outputs: DDC Hardware binary outputs (BOs) shall provide relay contact closures or triac outputs for momentary and maintained operation of output devices.

(1) Relay Contact Closures: Closures shall have a minimum duration of 0.1 second. Relays shall provide at least 180V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be one ampere at 24 Vac.

(2) Triac outputs: Triac outputs shall provide at least 180 V of isolation.

e. Pulse Accumulator: DDC Hardware pulse accumulators shall have the same characteristics as the BI. In addition, a buffer shall be provided to totalize pulses. The pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero upon operator's command.

2.13.3 Application Specific Controller (ASC)

Application Specific Controllers (ASCs) have a fixed factory-installed application program (i.e. ProgramID) with configurable settings. ASCs shall meet the following requirements in addition to the General DDC Hardware and DDC Hardware Input-Output (I/O) Function requirements:

a. ASCs shall be LonMark Certified.

b. Unless otherwise approved, all necessary Configuration Parameters and network configuration inputs (*ncis*) for the sequence and application in which the ASC is used shall be fully configurable through an LNS plug-in. This plug-in shall be submitted as specified for each type of ASC (manufacturer and model). (Note: configuration accomplished via hardware settings does not require configuration via plug-in)

c. Local Display Panel (LDP): The Local Display Panel shall be an Application Specific Controller (ASC) with a display and navigation buttons. It shall provide display and adjustment of SNVT inputs and SNVT outputs as shown.

2.13.4 General Purpose Programmable Controller (GPPC)

A General Purpose Programmable Controller (GPPC) is not installed with a fixed factory-installed application program. GPPCs shall meet the following requirements in addition to the general DDC Hardware requirements and Hardware Input-Output (I/O) Function:

a. The programmed GPPC shall conform to the LonMark Interoperability Guide.

b. All programming software required to program the GPPC shall be delivered to and licensed to the project site as specified.

c. Copies of the installed GPPC application programs as source code compatible with the supplied programming software shall be submitted as specified. The submitted GPPC application program shall be the complete application necessary for the GPPC to function as installed and be sufficient to allow replacement of the installed controller with a GPPC of the same type.

PART 3 EXECUTION

3.1 EXISTING CONDITIONS SURVEY

The Contractor shall perform a field survey, including testing and inspection of the equipment to be controlled and submit an Existing Conditions Report documenting the current status and it's impact on the Contractor's ability to meet this specification. For those items considered nonfunctional, the Contractor shall provide (with the report) specification sheets, or written functional requirements to support the findings and the estimated costs to correct the deficiencies. As part of the report, the Contractor shall define the scheduled need date for connection to existing equipment.

3.2 CONTROL SYSTEM INSTALLATION

3.2.1 General Installation Requirements

3.2.1.1 HVAC Control System

The HVAC control system shall be completely installed, tested and ready for operation. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exterior shall be made watertight. The HVAC control system installation shall provide clearance for control system maintenance by maintaining access space required to calibrate, remove, repair, or replace control system devices. The control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.2.1.2 Device Mounting Criteria

All devices shall be installed in accordance with manufacturer's recommendations and as specified and shown. Control devices to be installed in piping and ductwork shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements shall not be used except as specified. Spare thermowells shall be installed adjacent to each thermowell containing a sensor and as shown. Devices located outdoors shall have a weathershield.

3.2.1.3 Labels and Tags

Labels and tags shall be keyed to the unique identifiers shown on the As-Built drawings. All Enclosures and DDC Hardware shall be labeled. All sensors and actuators in mechanical rooms shall be tagged. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient. Duct static pressure taps shall be tagged at the location of the pressure tap. Tags shall be plastic or metal and shall be mechanically attached directly to each device or attached by a metal chain or wire. Labels exterior to

protective enclosures shall be engraved plastic and mechanically attached to the enclosure or DDC Hardware. Labels inside protective enclosures may attached using adhesive, but shall not be hand written.

3.2.2 DDC Hardware

DDC Hardware shall be installed in an enclosure. Except for DDC Hardware used to control Terminal Units, where multiple pieces of DDC Hardware are used to execute one sequence all DDC Hardware executing that sequence shall be on a common local control bus and isolated from all other DDC Hardware via an CEA-709.1B Router or CEA-709.3 Repeater. All DDC Hardware installed shall have an CEA-709.1B domain.

3.2.3 Local Display Panel (LDP)

Local Display Panels shall be installed in each mechanical room containing an air handler and shall provide SNVT inputs for display and outputs for adjusting SNVT values as shown on the Points Schedule.

3.2.4 Gateways

Gateways may be used for communication with non-CEA-709.1B control hardware subject to all of the following limitations:

a. Each gateway shall communicate with and perform protocol translation for non-CEA-709.1B control hardware controlling one and only one package unit.

b. Non-CEA-709.1B control hardware shall not be used for controlling built-up units.

c. Non-CEA-709.1B control hardware shall not perform system scheduling functions.

3.2.5 Network Interface Jack

A standard network interface jack shall be provided for each node on the control network. For terminal unit controllers with hardwired thermostats this network interface jack shall be located at the thermostat or within 10 ft of the controller. Locating the interface jack at the thermostat is preferred. For all other nodes the network interface jack shall be located within 10 ft of the node. If the network interface jack is other than a 1/8 inch phone jack, the Contractor shall provide an interface cable with a standard 1/8 inch phone jack on one end and a connector suitable for mating with installed network interface jack on the other. No more than one type of interface cable shall be required to access all network interface jacks. Contractor shall furnish one interface cable(s).

3.2.6 Room Instrument Mounting

Room instruments, including but not limited to wall mounted thermostats and sensors located in occupied spaces shall be mounted 60 inches above the floor unless otherwise shown. Unless otherwise shown on the Thermostat Schedule:

a. Thermostats for Fan Coil Units shall be unit mounted.

b. All other Thermostats shall be wall mounted.

3.2.7 Indication Devices Installed in Piping and Liquid Systems

Gauges in piping systems subject to pulsation shall have snubbers. Gauges for steam service shall have pigtail fittings with cock. Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.

3.2.8 Duct Smoke Detectors

Duct smoke detectors will be provided in supply and return air ducts in accordance with Section 28 31 76 INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM.. Contractor shall connect the DDC System to the auxiliary contacts provided on the Smoke Detector as required for system safeties and to provide alarms to the DDC system.

3.2.9 Occupancy Sensors

A sufficient quantity of occupancy sensors shall be provided to provide complete coverage of the area (room or space). Occupancy sensors shall be installed in accordance with NFPA 70 requirements and the manufacturer's instructions. Occupancy sensors shall not be located within 6 feet of HVAC outlets or heating ducts. PIR and dual-technology PIR/ultrasonic sensors shall not be installed where they can "see" beyond any doorway. Ultrasonic sensors shall not be installed in spaces containing ceiling fans. Sensors shall detect motion to within 2 feet of all room entrances and shall not trigger due to motion outside the room. The off-delay timer shall be set to 15 minutes unless otherwise shown. All sensor adjustments shall be made prior to beneficial occupancy, but after installation of furniture systems, shelving, partitions, etc. Each controlled area shall have one hundred percent coverage capable of detecting small hand-motion movements, accommodating all occupancy habits of single or multiple occupants at any location within the controlled room.

3.2.10 Temperature Limit Switch

A temperature limit switch (freezestat) shall be provided to sense the temperature at the location shown. A sufficient number of temperature limit switches (freezestats) shall be installed to provide complete coverage of the duct section. Manual reset limit switches shall be installed in approved, accessible locations where they can be reset easily. The temperature limit switch (freezestat) sensing element shall be installed in a serpentine pattern and in accordance with the manufacturer's installation instructions.

3.2.11 Averaging Temperature Sensing Elements

Sensing elements shall be installed in a serpentine pattern located as shown.

3.2.12 Air Flow Measurement Arrays (AFMA))

Outside Air AFMAs shall be located downstream from the Outside Air filters. Pitot Tube AFMA shall not be used if the expected velocity measurement is below 700 fpm or for outside airflow measurements.

3.2.13 Duct Static Pressure Sensors

The duct static pressure sensing tap shall be located at 75% to 100% of the distance between the first and last air terminal units. If the transmitter

is wired in a homerun configuration to an AHU controller, the transmitter shall be located in the same enclosure as the air handling unit (AHU) controller(s) for the AHU serving the terminal units.

3.2.14 Relative Humidity Sensors

Relative humidity sensors in supply air ducts shall be installed at least 10 feet downstream of humidity injection elements.

3.2.15 Flowmeters

The minimum straight unobstructed piping for the flowmeter installation shall be at least 10 pipe diameters upstream and at least 5 pipe diameters downstream and in accordance with the manufacturer's installation instructions.

3.2.16 Dampers

3.2.16.1 Damper Actuators

Actuators shall not be mounted in the air stream. Multiple actuators shall not be connected to a common drive shaft. Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

3.2.16.2 Damper Installation

Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking (parallelogramming), bowing, or other installation error. Blades shall close completely and leakage shall not exceed that specified at the rated static pressure. Structural support shall be used for multi-section dampers. Acceptable methods include but are not limited to U-channel, angle iron, corner angles and bolts, bent galvanized steel stiffeners, sleeve attachments, braces, and building structure. Where multi-section dampers are installed in ducts or sleeves, they shall not sag due to lack of support. Jackshafts shall not be used to link more than three damper sections. Blade to blade linkages shall not be used. Outside and return air dampers shall be installed such that their blades direct their respective air streams towards each other to provide for maximum mixing of air streams.

3.2.17 Valves

3.2.17.1 Ball Valves

Two-position (open/closed) ball valves may only be used on chilled water, condenser water, hot water, or steam applications. Modulating ball valves may only be used for chilled water and condenser water applications (modulating ball valves shall not be used on steam or hot water applications). In modulating applications a characterizing equal-percentage disc shall be used.

3.2.17.2 Butterfly Valves

In two-way control applications, valve travel shall be limited to 70% (60 degrees) open position.

3.2.18 Local Gauges for Actuators

Pneumatic actuators shall have an accessible and visible pressure gauge installed in the tubing lines at the actuator as shown.

3.2.19 Wire and Cable

Wire and Cable shall be installed without splices between control devices and in accordance with NFPA 70 and NFPA 90A. Instrumentation grounding shall be installed per the device manufacturer's instructions and as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Ground rods installed by the Contractor shall be tested as specified in IEEE Std 142. Cables and conductor wires shall be tagged at both ends, with the identifier shown on the shop drawings. Electrical work shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and as shown. Wiring external to enclosures shall be run as follows:

a. Wiring other than low-voltage control and low-voltage network wiring shall be installed in raceways.

b. Low-voltage control and low-voltage network wiring not in suspended ceilings over occupied spaces shall be installed in raceways, except that nonmetallic-sheathed cables or metallic-armored cables may be installed as permitted by NFPA 70.

c. Low-voltage control and low-voltage network wiring in suspended ceilings over occupied spaces shall be installed in raceways, except:

(1) nonmetallic-sheathed cables or metallic-armored cables may be installed as permitted by NFPA 70.

(2) plenum rated cable in suspended ceilings over occupied spaces may be run without raceways.

3.2.20 Copper Tubing

Copper tubing shall be hard-drawn in exposed areas and either hard-drawn or annealed in concealed areas. Only tool-made bends shall be used. Fittings for copper tubing shall be brass or copper solder joint type except at connections to apparatus, where fittings shall be brass compression type.

3.2.21 Plastic Tubing

Plastic tubing shall be run within covered raceways or conduit except when otherwise specified. Plastic tubing shall not be used for applications where the tubing could be subjected to a temperature exceeding 130 degrees F. Fittings for plastic tubing shall be for instrument service and shall be brass or acetal resin of the compression or barbed push-on type. Except in walls and exposed locations, plastic multitube instrument tubing bundle without conduit or raceway protection may be used where a number of air lines run to the same points, provided the multitube bundle is enclosed in a protective sheath, is run parallel to the building lines and is adequately supported as specified.

3.3 DRAWINGS AND CALCULATIONS

Contractor shall prepare and submit shop drawings.

3.3.1 Network Bandwidth Usage Calculations

The Contractor shall perform Building Control Network Bandwidth Usage Calculations for a normally loaded and a heavily loaded control network. Calculations shall be performed for network traffic on the backbone.

1) A heavily loaded control network is characterized as one performing the following activities simultaneously:

a. Transmitting every point in the building indicated on Points Schedules as being available to the UMCS in response to polling requests at 15-minute intervals (for trending at UMCS).

b. Transmitting five points to the UMCS in response to polling requests at 2-second intervals.

c. Transmitting 100 points to the UMCS in response to polling requests at 5-second intervals.

d. Transmitting occupancy commands from the UMCS to every system schedule sequence in a one-minute interval.

e. Transmitting occupancy override commands from the UMCS to every system schedule sequence in a one-minute interval.

2) A normally loaded control network is characterized as one performing the following activities simultaneously:

a. Transmitting every point in the building indicated on Points Schedules as requiring a trend to the UMCS in response to polling requests at 15-minute intervals (for trending at UMCS).

b. Transmitting 50 points to the UMCS in response to polling requests at 5-second intervals.

c. Transmitting occupancy commands from the UMCS to every system scheduler sequence in a one-minute interval.

3.3.2 DDC Contractor Design Drawings

Drawings shall be on ISO A1 34 by 22 inches or A3 17 by 11 inches sheets in the form and arrangement shown. The drawings shall use the same abbreviations, symbols, nomenclature and identifiers shown. Each control system element on a drawing shall be assigned a unique identifier as shown. The DDC Contractor Design Drawings shall be delivered together as a complete submittal. Deviations shall be approved by the Contracting Officer. DDC Contractor Design Drawings shall include the following:

a. Drawing Index and HVAC Design Drawing Legend: The HVAC Control System Drawing Index shall show the name and number of the building, military site, State or other similar designation, and Country. The Drawing Index shall list all Contractor Design Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. The Design Drawing Legend shall show and describe all symbols, abbreviations and acronyms used on the Design Drawings.

b. Valve Schedule: The valve schedule shall contain each valve's unique identifier, size, flow coefficient Kv (Cv), pressure drop at specified flow rate, spring range, positive positioner range, actuator

size, close-off pressure to torque data, dimensions, and access and clearance requirements data. The valve schedule shall contain actuator selection data supported by calculations of the force required to move and seal the valve, access and clearance requirements. A valve schedule shall be submitted for each HVAC system.

c. Damper Schedule: The damper schedule shall contain each damper's unique identifier, type (opposed or parallel blade), nominal and actual sizes, orientation of axis and frame, direction of blade rotation, actuator size and spring ranges, operation rate, positive positioner range, location of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. The Damper Schedule shall include the AMCA 500-D maximum leakage rate at the operating static-pressure differential. A damper schedule shall be submitted for each HVAC system.

d. Thermostat and Occupancy Sensor Schedule: The thermostat and occupancy sensor schedule shall contain each thermostat's unique identifier, room identifier and control features and functions as shown. A thermostat and occupancy sensor schedule shall be submitted for each HVAC system.

e. Critical Alarm Handling Schedule: The critical alarm handling schedule shall contain the same fields as the critical alarm handling schedule Contract Drawing with Contractor updated information and any other project-specific information required to implement the alarm handling function. A critical alarm handling schedule shall be submitted for each HVAC system.

f. Equipment Schedule: The equipment schedule shall contain the unique identifier, manufacturer, model number, part number and descriptive name for each control device, hardware and component provided under this specification. An equipment schedule shall be submitted for each HVAC system.

g. Occupancy Schedule: The occupancy schedule drawing shall contain the same fields as the occupancy schedule Contract Drawing with Contractor updated information. An occupancy schedule shall be submitted for each HVAC system.

h. Points Schedule: The Points Schedule drawing shall contain the same fields as the Points Schedule Contract Drawing with Contractor updated information. A Points Schedule shall be submitted for each HVAC system.

i. Riser diagram of building control network: The Riser Diagram of the Building Control Network shall show all network cabling, DDC Hardware, and Network Hardware including:

(1) All DDC Hardware with room number and location within room.

(2) DDC Hardware unique identifiers and common descriptive names.

(3) All Network hardware with room number and location within room.

(4) Network hardware unique identifiers.

(5) All cabling.

(6) Room number and location within room of all cabling termination points.

(7) Room number and location within room of all network interface jacks.

j. A single riser diagram shall be submitted for each building.

k. Control System Schematics: The control system schematics shall be in the same form as the control system schematic Contract Drawing with Contractor updated information. A control system schematic shall be submitted for each HVAC system.

l. Sequences of Operation: The HVAC control system sequence of operation and shall be in the same format as the Contract Drawings and shall refer to the devices by their unique identifiers. No operational deviations from specified sequences will be permitted without prior written approval of the Government. Sequences of operation shall be submitted for each HVAC control system.

m. Controller, Motor Starter and Relay Wiring Diagram: The controller wiring diagrams shall be functional wiring diagrams which show the interconnection of conductors and cables to each controller and to the identified terminals of input and output devices, starters and package equipment. The wiring diagrams shall show necessary jumpers and ground connections. The wiring diagrams shall show the labels of all conductors. Sources of power required for control systems and for packaged equipment control systems shall be identified back to the panel board circuit breaker number, controller enclosures, magnetic starter, or packaged equipment control circuit. Each power supply and transformer not integral to a controller, starter, or packaged equipment shall be shown. The connected volt-ampere load and the power supply volt-ampere rating shall be shown. Wiring diagrams shall be submitted for each HVAC control system.

3.3.3 Draft As-Built Drawings

The Contractor shall update the Contractor Design Drawings with all as-built data and submit as specified.

3.3.4 Final As-Built Drawings

The Contractor shall update the Draft As-Built Drawings with all final as-built data and submit as specified.

3.4 CONTROLLER TUNING

The Contractor shall tune each controller in a manner consistent with that described in the ASHRAE FUN IP. Tuning shall consist of adjustment of the proportional, integral, and where applicable, the derivative (PID) settings to provide stable closed-loop control. Each loop shall be tuned while the system or plant is operating at a high gain (worst case) condition, where high gain can generally be defined as a low-flow or low-load condition. Upon final adjustment of the PID settings, in response to a change in controller setpoint, the controlled variable shall settle out at the new setpoint with no more than two (2) oscillations above and below setpoint. Upon settling out at the new setpoint the controller output shall be steady. With the exception of naturally slow processes such as zone

temperature control, the controller shall settle out at the new setpoint within five (5) minutes. The Contractor shall return the controller to its original setpoint and shall record and submit the final PID configuration settings with the O&M Instructions and on the associated Points Schedule.

3.5 START-UP AND START-UP TEST

The Contractor shall perform the following startup tests for each control system to ensure that the described control system components are installed and functioning per this specification.

a. General: The Contractor shall adjust, calibrate, measure, program, configure, set the time schedules, set alarms, and otherwise perform all necessary actions to ensure that the systems function as specified and shown in the sequence of operation and other contract documents.

b. Systems Check: An item-by-item check shall be performed for each HVAC system;

(1) Step 1 - System Inspection: With the system shut down, it shall be verified that power and main air are available where required and that all output devices are in their failsafe and normal positions. Each local display panel and each M&C Client shall be inspected to verify that all displays indicate shutdown conditions.

(2) Step 2 - Calibration Accuracy Check: A two-point accuracy check of the calibration of each HVAC control system sensing element and transmitter shall be performed by comparing the SNVT output from the DDC Hardware the sensor is connected to the actual value of the variable measured at the sensing element. Digital indicating test instruments shall be used, such as digital thermometers, motor-driven psychrometers, and tachometers. The test instruments shall be at least twice as accurate as the specified sensor accuracy. The calibration of the test instruments shall be traceable to National Institute Of Standards And Technology standards. The first check point shall be with the HVAC system in the shutdown condition, and the second check point shall be with the HVAC system in an operational condition. Calibration checks shall verify that the sensing element-to-DDC system readout accuracies at two points are within the specified product accuracy tolerances. If not, the device shall be recalibrated or replaced and the calibration check repeated.

(3) Step 3 - Actuator Range Check: With the system running, a signal shall be applied to each actuator through the DDC Hardware controller. Proper operation of the actuators and positioners for all actuated devices shall be verified and the signal levels shall be recorded for the extreme positions of each device. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. Where applicable, it shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

c. Weather Dependent Test: Weather dependent test procedures that cannot be performed by simulation shall be performed in the appropriate climatic season. When simulation is used, the actual results shall be

verified in the appropriate season.

Test Report: Upon completion of the Start-Up Test, the Contractor shall prepare and submit a Start-Up and Start-Up Testing Report documenting the results of the tests performed and certifying that the system is installed and functioning per this specification, and is ready for the Performance Verification Test (PVT).

3.6 PERFORMANCE VERIFICATION TEST (PVT)

3.6.1 PVT Procedures

The performance verification test procedures shall explain, step-by-step, the actions and expected results that will demonstrate that the control system performs in accordance with the sequences of operation, and other contract documents. The PVT shall include a one-point accuracy check of each sensor. The PVT shall include inlet and outlet air temperature measurements for all AHU-dependent terminal units. The PVT Procedure shall describe a methodology to measure and trend the network bandwidth usage on the network backbone and compare it to the Bandwidth Usage Calculation submittal. A control system performance verification test equipment list shall be included that lists the equipment to be used during performance verification testing. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

3.6.2 PVT Execution

The Contractor shall demonstrate compliance of the control system with the contract documents. Using test plans and procedures approved by the Government, the Contractor shall demonstrate all physical and functional requirements of the project. The performance verification test shall show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. The performance verification test shall measure and trend the Network Bandwidth Usage and compare it to the Bandwidth Usage Calculation submittal. The performance verification test shall not be started until after receipt by the Contractor of written permission by the Government, based on Government approval of the Start-Up and Start-Up Testing Report and completion of balancing. The tests shall not be conducted during scheduled seasonal off periods of base heating and cooling systems.

3.6.3 PVT Report

Contractor shall prepare a PVT report documenting all tests performed during the PVT and their results. The PVT report shall include all tests in the PVT Procedures and any other testing performed during the PVT. Failures and repairs shall be documented with test results.

3.7 TRAINING

A training course shall be conducted for 6 operating staff members designated by the Government in the maintenance and operation of the system, including specified hardware and software. The training period, for a total of 32 hours of normal working time, shall be conducted within 30 days after successful completion of the performance verification test. The training course shall be conducted at the project site and the Government reserves the right to videotape the training sessions for later use. Audiovisual equipment and 4 sets of all other training materials and

supplies shall be provided. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

3.7.1 Training Documentation

The Contractor shall prepare training documentation consisting of:

a. Course Attendee List: A List of course attendees which shall be developed in coordination with and signed by the Controls HVAC Electrical shop supervisor.

b. Training Manuals: Training manuals shall include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. Where the Contractor presents portions of the course material by audiovisuals, copies of those audiovisuals shall be delivered to the Government as a part of the printed training manuals. Training manuals shall be delivered for each trainee with two additional copies delivered for archival at the project site.

3.7.2 Training Course Content

For guidance in planning the required instruction, the Contractor shall assume that attendees will have a high school education or equivalent, and are familiar with HVAC systems. The training course shall cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each controller enclosure, the layout of one of each type of unitary equipment and the locations of each, the location of each control device external to the panels, the location of the compressed air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, repair procedures, use of LNS Plug-ins, and use of the GPPC Programming software. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. The results of the performance verification test and the Start-Up and Start-Up Testing Report shall be presented as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness.

APPENDIX A

QC CHECKLIST

This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such.

This checklist is for (check one:)

Pre-Construction QC Checklist Submittal (Items 1-5) |____|

Post-Construction QC Checklist Submittal (Items 1-12) |____|

Close-out QC Checklist Submittal (Items 1-19) |____|

Initial each item in the space provided (|____|) verifying that requirement has been met.

Items verified for Pre-Construction, Post-Construction and Closeout QC Checklists Submittal:

1 Network bandwidth calculations have been performed, and the backbone type (Ethernet or TP/FT-10) has been determined based on these calculations. |____|

2 All DDC Hardware (nodes) are numbered on Control System Schematic Drawings. |____|

3 Signal lines on Control System Schematic are labeled with the signal type. |____|

4 Local Display Panel (LDP) Locations are shown on Control System Schematic drawings. |____|

5 Points Schedule drawings have been sub-divided by device (DDC Hardware), including DDC Hardware node numbers. |____|

Items verified for Post-Construction and Closeout QC Checklist Submittal:

6 All DDC Hardware is installed on a TP/FT-10 local control bus. |____|

7 All Application Specific Controllers (ASCs) are LonMark certified. |____|

8 Communication between DDC Hardware is only via CEA-709.1B using SNVTs. Other protocols and network variables other than SNVTs have not been used. |____|

9 Explicit messaging has not been used. |____|

10 System Scheduler functionality has been installed for all HVAC systems and default schedules have been configured at each System Scheduler. |____|

11 All sequences are performed as specified using DDC Hardware. |____|

12 Training schedule and course attendee list has been developed and coordinated with shops and submitted. |____|

QC CHECKLIST

Items verified for Closeout QC Checklists Submittal:

13	Final As-built Drawings, including the Points Schedule drawings accurately represent the final installed system.	|____|
14	LonWorks Network Services (LNS) Database is up-to-date and accurately represents the final installed system.	|____|
15	LNS Plug-ins have been submitted for all ASCs.	|____|
16	Programming software has been submitted for all General Purpose Programmable Controllers (GPPCs).	|____|
17	All software has been licensed to the Government	|____|
18	O&M Instructions have been completed and submitted.	|____|
19	Training course has been completed.	|____|

_____

(QC Representative Signature) (Date)

-- End of Section --

SECTION 23 11 25

FACILITY GAS PIPING
11/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GAS ASSOCIATION (AGA)

AGA B109.1	(2000)Diaphragm-Type Gas Displacement Meters (Under 500 cubic ft./hour Capacity)
AGA B109.3	(2000)Rotary-Type Gas Displacement Meters
AGA XR0603	(2006) AGA Plastic Pipe Manual for Gas Service

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.45	(1995) Flexible Connectors of Other Than All-Metal Construction for Gas Appliances

AMERICAN PETROLEUM INSTITUTE (API)

API 570	(1998; Addendum 1 2000, Addendum 2 2001, Addendum 3 2003, Addendum 4 2006) Piping Inspection Code
API RP 1110	(2007) Pressure Testing of Liquid Petroleum Pipelines
API RP 2003	(2008) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents
API RP 2009	(2002) Safe Welding, Cutting, and Hot Work Practices in the Petroleum and Petrochemical Industries
API Spec 15LR	(2001) Specification for Low Pressure Fiberglass Line Pipe and Fittings
API Spec 5CT	(2005; Errata 2006; Errata 2006) Specification for Casing and Tubing
API Spec 6D	(2008; Errata 2008) Specification for Pipeline Valves
API Std 598	(2004) Valve Inspecting and Testing
API Std 607	(2005) Fire Test for Soft-Seated

Quarter-Turn Valves

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 25	(2008) Standard for Earthquake-Activated Automatic Gas Shutoff Devices

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2004; Errata 2004) Specification for Filler Metals for Brazing and Braze Welding
AWS WHB-2.9	(2004) Welding Handbook; Volume Two - Welding Processes

ASME INTERNATIONAL (ASME)

ASME A13.1	(2007) Scheme for the Identification of Piping Systems
ASME B1.20.1	(1983; R 2006) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2005) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.11	(2005) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2005) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.3	(2006) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.33	(2002; R 2007) Manually Operated Metallic Gas Valves for Use in Gas Piping Systems Up to 125 psi, Sizes NPS 1/2 - NPS 2
ASME B16.39	(1998; R 2006) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.5	(2003) Standard for Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24
ASME B16.9	(2007) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.9	(2008) Building Services Piping
ASME B36.10M	(2004) Standard for Welded and Seamless Wrought Steel Pipe
ASME B40.100	(2006) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2007; Addenda 2008) Boiler and Pressure Vessel Code; Section IX, Welding and

Brazing Qualifications

ASME BPVC SEC VIII D1 (2007; Addenda 2008) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

ASTM INTERNATIONAL (ASTM)

ASTM 01.01 (2008) Steel - Piping, Tubing, Fittings

ASTM A 105/A 105M (2005) Standard Specification for Carbon Steel Forgings for Piping Applications

ASTM A 181/A 181M (2006) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping

ASTM A 513 (2008) Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing

ASTM A 53/A 53M (2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A 666 (2003) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar

ASTM B 210 (2004) Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes

ASTM B 241/B 241M (2002) Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube

ASTM B 280 (2008) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

ASTM B 88 (2003) Standard Specification for Seamless Copper Water Tube

ASTM D 2513 (2008a) Thermoplastic Gas Pressure Pipe, Tubing, and Fittings

ASTM D 2517 (2006) Reinforced Epoxy Resin Gas Pressure Pipe and Fittings

ASTM F 2015 (2000) Standard Specification for Lap Joint Flange Pipe End Applications

CANADIAN STANDARDS ASSOCIATION (CSA)

CSA 3.11-CAN/CGA (1988; R 2003) Lever Operated Pressure Lubricated Plug Type Gas Shut-Off Valves

CSA AMERICA, INC. (CSA/AM)

CSA/AM Z21.15 (1997; R 2003; A 2006) Manually Operated

	Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves
CSA/AM Z21.24	(2006) Connectors for Gas Appliances
CSA/AM Z21.41	(2003; A 2005; Errata 2007) Quick-Disconnect Devices for Use with Gas Fuel Appliances
CSA/AM Z21.69	(2002; Addenda A 2003; Addenda B 2006; R 2007) Connectors for Movable Gas Appliances
CSA/AM Z21.80	(2005: R 2008) Line Pressure Regulators

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(1998) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2002) Standard for Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(2003; R 2004) Standard for Pipe Hangers and Supports - Selection and Application

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2008) National Fuel Gas Code
NFPA 58	(2007; Amendment 1 2007; Amendment 2 2007; Amendment 3 2007; Amendment 4 2008) Liquefied Petroleum Gas Code
NFPA 70	(2007; AMD 1 2008) National Electrical Code - 2008 Edition

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA Seismic Restraint Mnl	(1998; Addendum 2000, 2nd Ed) Seismic Restraint Manual: Guidelines for Mechanical Systems

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6	(2000; E 2004) Commercial Blast Cleaning

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2007) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL Gas&Oil Dir	(2008) Flammable and Combustible Liquids and Gases Equipment Directory

1.2 SYSTEM DESCRIPTION

The gas piping system includes natural gas piping and appurtenances from point of connection with supply system, as indicated, to gas operated equipment within the facility. Submit operation and maintenance data in accordance with 23 03 00.00 20 BASIC MECHANCIAL MATERIALS AND METHODS applies to this section, with additions and modifications specified herein. Provide cathodically protected insulating joints connecting aboveground piping from the meter to the building, with lightning arrestors, zinc grounding cells conforming to API RP 2003, installed where indicated.

1.2.1 Gas Facility System and Equipment Operation

Include shop drawings showing piping layout, locations of system valves, gas line markers; step-by-step procedures for system start up, operation and shutdown (index system components and equipment to the system drawings); isolation procedures including valve operation to shutdown or isolate each section of the system (index valves to the system maps and provide separate procedures for normal operation and emergency shutdown if required to be different). Submit Data package No. 4.

1.2.2 Gas Facility System Maintenance

Include maintenance procedures and frequency for system and equipment; identification of pipe materials and manufacturer by locations, pipe repair procedures, and jointing procedures at transitions to other piping material or material from a different manufacturer. Submit Data Package No.4.

1.2.3 Gas Facility Equipment Maintenance

Include identification of valves, shut-offs, disconnects, and other equipment by materials, manufacturer, vendor identification and location; maintenance procedures and recommended tool kits for valves and equipment; recommended repair methods (i.e., field repair, factory repair, or replacement) for each valve and piece of equipment; and preventive maintenance procedures, possible failure modes and troubleshooting guide. Submit Data Package No. 3.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Gas Piping System; G, DO

SD-03 Product Data

Pipe and Fittings; G, DO
Gas equipment connectors; G, DO
Gas Piping System; G, DO
Pressure regulators; G, DO
Risers; G, DO
Transition fittings; G, DO
Valves; G, DO

Valve box; G, DO
Warning and identification tape; G, DO

SD-06 Test Reports

Testing; G, DO
Pressure Tests; G, DO

1.4 QUALITY ASSURANCE

Submit manufacturer's descriptive data and installation instructions for approval for compression-type mechanical joints used in joining dissimilar materials and for insulating joints. Mark all valves, flanges and fittings in accordance with MSS SP-25.

1.4.1 Welding Qualifications

a. Weld piping in accordance with qualified procedures using performance qualified welders and welding operators in accordance with API RP 2009, ASME BPVC SEC IX, and ASME B31.9. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.9. Notify the Contracting Officer at least 24 hours in advance of tests, and perform at the work site if practicable.

b. Submit a certified copy of welders procedures and qualifications metal and PE in conformance with ASME B31.9 for each welder and welding operator. Submit the assigned number, letter, or symbol that will be used in identifying the work of each welder to the Contracting Officer. Weld all structural members in accordance with Section 05 05 23 WELDING, STRUCTURAL, and in conformance with AWS A5.8/A5.8M, and AWS WHB-2.9.

1.4.2 Jointing Thermoplastic and Fiberglass Piping

Perform all jointing of piping using qualified joiners and qualified procedures in accordance with AGA XR0603. Furnish the Contracting Officer with a copy of qualified procedures and list of and identification symbols of qualified joiners. Submit manufacturer's installation instructions and manufacturer's visual joint appearance chart, including all PE pipe and fittings.

1.4.3 Shop Drawings

Submit drawings for complete Gas Piping System, within 30 days of contract award, showing location, size and all branches of pipeline; location of all required shutoff valves; and instructions necessary for the installation of gas equipment connectors and supports. Include LP storage tank, pad, and mounting details.

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, transport, and store plastic pipe and fittings carefully. Plug or cap pipe and fittings ends during transportation or storage to minimize dirt and moisture entry. Do not subject piping to abrasion or concentrated external loads. Discard PE pipe sections and fittings that have been damaged.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Asbestos or products containing asbestos are not allowed. Submit catalog data and installation instructions for pipe, valves, all related system components, pipe coating materials and application procedures. Conform to NFPA 54 and with requirements specified herein. Provide supply piping to appliances or equipment at least as large as the inlets thereof.

2.2 GAS PIPING SYSTEM AND FITTINGS

2.2.1 Steel Pipe, Joints, and Fittings

a. Pipe: Black carbon steel in accordance with ASTM A 53/A 53M, Schedule 40, threaded ends for sizes 2 inches and smaller; otherwise, plain end beveled for butt welding.

b. Threaded Fittings: ASME B16.3, black malleable iron.

c. Socket-Welding Fittings: ASME B16.11, forged steel.

d. Butt-Welding Fittings: ASME B16.9, with backing rings of compatible material.

e. Unions: ASME B16.39, black malleable iron.

f. Flanges and Flanged Fittings: ASME B16.5 steel flanges or convoluted steel flanges conforming to ASME BPVC SEC VIII D1, with flange faces having integral grooves of rectangular cross sections which afford containment for self-energizing gasket material.

Provide steel pipe conforming to ASME B36.10M; and malleable-iron threaded fittings conforming to ASME B16.1 and ASME B16.3. Provide steel pipe flanges and flanged fittings, including bolts, nuts, and bolt pattern in accordance with ASME B16.5 and ASTM A 105/A 105M. Provide wrought steel buttwelding fittings conforming to ASME B16.9. Provide socket welding and threaded forged steel fittings conforming to ASME B16.11 and ASTM A 181/A 181M, Class 60.

2.2.2 Aluminum Alloy Pipe and Tubing, Joints, and Fittings

Provide aluminum alloy pipe conforming to ASTM B 241/B 241M, except that alloy 5456 is not allowed. Mark the ends of each length of pipe indicating it conforms to NFPA 54 NFPA 58. Thread, flange, braze, or weld pipe joints. Provide aluminum alloy tubing conforming to ASTM B 210, Type A or B, or ASTM B 241/B 241M, Type A or equivalent, with joints made up with gas tubing fittings recommended by the tubing manufacturer.

2.2.3 Copper Tubing, Joints and Fittings

Provide copper tubing conforming to ASTM B 88, Type K or L, or ASTM B 280, with tubing joints made up with tubing fittings recommended by the tubing

manufacturer. Provide copper and copper alloy press fittings, with sealing elements of Hydrogenated Nitrile Butadiene Rubber (HNBR), factory installed, or an alternative supplied by the fitting manufacturer.

2.2.4 Steel Tubing, Joints and Fittings

Provide steel tubing conforming to ASTM 01.01, and ASTM A 513, with tubing joints made up with gas tubing fittings recommended by the tubing manufacturer.

2.2.5 Thermoplastic Pipe, Tubing, Joints, and Fittings

Provide thermoplastic pipe, tubing,casing and joints and fittings conforming to ASTM D 2513 and API Spec 5CT.

2.2.6 Fiberglass Pipe, Joints, and Fittings

Provide fiberglass piping systems conforming to ASTM D 2517 and API Spec 15LR.

2.2.7 Sealants for Steel Pipe Threaded Joints

Provide joint sealing compound as listed in UL Gas&Oil Dir, Class 20 or less. For taping, use tetrafluoroethlene tape conforming to UL Gas&Oil Dir.

2.2.8 Warning and Identification

Provide pipe flow markings, warning and identification tape, and metal tags as required.

2.2.9 Flange Gaskets

Provide gaskets of nonasbestos compressed material in accordance with ASME B16.21, 1/16 inch thickness, full face or self-centering flat ring type, containing aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR) suitable for a maximum 600 degree F service, to be used for hydrocarbon service.

2.2.10 Pipe Threads

Provide pipe threads conforming to ASME B1.20.1.

2.2.11 Escutcheons

Provide chromium-plated steel or chromium-plated brass escutcheons, either one piece or split pattern, held in place by internal spring tension or set screw.

2.2.12 Gas Transition Fittings

a. Provide steel to plastic (PE) designed for steel-to-plastic with tapping tee or sleeve conforming to AGA XR0603 requirements for transitions fittings.. Coat or wrap exposed steel pipe with heavy plastic coating.

b. Plastic to Plastic: Manufacturer's standard bolt-on (PVC to PE) plastic tapping saddle tee, UL listed for gas service, rated for 100 psig, and O-ring seals. Manufacturer's standard slip-on PE mechanical coupling, molded, with stainless-steel ring support conforming to

ASTM A 666, O-ring seals, and rated for 150 psig gas service. Manufacturer's standard fused tapping (PE-to-PE) tee assembly with shut-off feature.

c. Provide lever operated pressure lubricated plug type gas shut-off valve conforming to CSA 3.11-CAN/CGA.

2.2.13 Insulating Pipe Joints

2.2.13.1 Insulating Joint Material

Provide insulating joint material between flanged or threaded metallic pipe systems where shown to control galvanic or electrical action.

2.2.13.2 Threaded Pipe Joints

Provide threaded pipe joints of steel body nut type dielectric unions with insulating gaskets.

2.2.13.3 Flanged Pipe Joints

Provide joints for flanged pipe consisting of full face sandwich-type flange insulating gasket of the dielectric type, insulating sleeves for flange bolts, and insulating washers for flange nuts. Provide lap joint flange pipe ends conforming to ASTM F 2015.

2.2.14 Flexible Connectors

a. Provide flexible connectors for connecting gas utilization equipment to building gas piping conforming to CSA/AM Z21.24, ANSI Z21.45, or CSA/AM Z21.41 for quick disconnect devices, and flexible connectors for movable food service equipment conforming to CSA/AM Z21.69.

b. Do not install the flexible connector through the appliance cabinet face. Provide rigid metallic pipe and fittings to extend the final connection beyond the cabinet, except when appliance is provided with an external connection point.

2.3 VALVES

Provide lockable shutoff or service isolation valves as indicated in the drawings conforming to the following:

2.3.1 Valves 2 Inches and Smaller

Provide valves 2 inches and smaller conforming to ASME B16.33 of materials and manufacture compatible with system materials used.

2.3.2 Valves 2-1/2 Inches and Larger

Provide valves 2-1/2 inches and larger of carbon steel conforming to API Spec 6D, Class 150.

2.4 RISERS

Provide manufacturer's standard riser, transition from plastic to steel pipe with 7 to 12 mil thick epoxy coating. Use swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve.

Provide remote bolt-on or bracket or wall-mounted riser supports as indicated on the drawings.

2.5 PIPE HANGERS AND SUPPORTS

Provide pipe hangers and supports conforming to MSS SP-58 and MSS SP-69.

2.6 METERING, REGULATORS AND SHUTOFF VALVES

Provide diaphragm-type meter conforming to AGA B109.1 rotary-type displacement meter conforming to AGA B109.3 as required by local gas utility supplier, including valve box conforming to NFPA 54. Provide pressure gauges and attachments conforming to ASME B40.100. Provide regulators conforming to CSA/AM Z21.80 for line pressure regulators. Provide shutoff valves conforming to CSA/AM Z21.15 for manually controlled gas shutoff valves.

2.7 SEISMIC PROVISIONS

Provide earthquake automatic gas shutoff valve conforming to ASCE 25, SMACNA Seismic Restraint Mnl, and UL listed or AGA listed or International Association of Plumbing and Mechanical Officials (IAPMO) listed. The valve may be either pendulum or ball construction with electronic or electric actuator.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy or areas of conflict before performing the work.

3.2 GAS PIPING SYSTEM

Provide a gas piping system from the point of delivery, defined as the outlet of the meter set assembly, shutoff valve, to the connections to each gas utilization device.

3.2.1 Protection and Cleaning of Materials and Components

Protect equipment, pipe, and tube openings by closing with caps or plugs during installation. At the completion of all work, thoroughly clean the entire system.

3.2.2 Workmanship and Defects

Piping, tubing and fittings shall be clear and free of cutting burrs and defects in structure or threading and shall be thoroughly brushed and chip-and scale-blown. Repair of defects in piping, tubing or fittings is not allowed; replace defective items when found.

3.3 PROTECTIVE COVERING

3.3.1 Underground Metallic Pipe

Protect buried metallic piping from corrosion with protective coatings as specified in Section 33 51 15 NATURAL-GAS / LIQUID PETROLEUM GAS DISTRIBUTION. When dissimilar metals are joined underground, use gastight

insulating fittings.

3.3.2 Aboveground Metallic Piping Systems

3.3.2.1 Ferrous Surfaces

Touch up shop primed surfaces with ferrous metal primer. Solvent clean surfaces that have not been shop primed . Mechanically clean surfaces that contain loose rust, loose mill scale and other foreign substances by power wire brushing or commercial sand blasted conforming to SSPC SP 6 and prime with ferrous metal primer or vinyl type wash coat. Finish primed surfaces with two coats of exterior oil paint or vinyl paint.

3.3.2.2 Nonferrous Surfaces

Except for aluminum alloy pipe, do not paint nonferrous surfaces. Paint surfaces of aluminum alloy pipe and fittings to protect against external corrosion where they contact masonry, plaster, insulation, or are subject to repeated wettings by such liquids as water, detergents or sewage. Solvent-clean the surfaces and treat with vinyl type wash coat. Apply a first coat of aluminum paint and a second coat of alkyd gloss enamel or silicone alkyd copolymer enamel.

3.4 INSTALLATION

Install the gas system in conformance with the manufacturer's recommendations and applicable provisions of NFPA 54, AGA XR0603, and as indicated. Perform all pipe cutting without damage to the pipe, with an approved type of mechanical cutter, unless otherwise authorized. Use wheel cutters where practicable. On steel pipe 6 inches and larger, an approved gas cutting and beveling machine may be used. Cut thermoplastic and fiberglass pipe in accordance with AGA XR0603.

3.4.1 Metallic Piping Installation

Bury underground piping a minimum of 18 inches below grade. Make changes in direction of piping with fittings only; mitering or notching pipe to form elbows and tees or other similar type construction is not permitted. Branch connection may be made with either tees or forged branch outlet fittings. Provide branch outlet fittings which are forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Do not use aluminum alloy pipe in exterior locations or underground.

3.4.2 Metallic Tubing Installation

Install metallic tubing using gas tubing fittings approved by the tubing manufacturer. Make branch connections with tees. Prepare all tubing ends with tools designed for that purpose. Do not use aluminum alloy tubing in exterior locations or underground.

3.4.3 Thermoplastic and Fiberglass Piping, Tubing, and Fittings

Installation of thermoplastic and fiberglass piping, tubing, and fittings is permitted only outside and underground. Bury piping a minimum of 18 inches below grade. Install the piping to avoid excessive stresses due to thermal contraction, and use only where indicated.

3.4.4 Connections Between Metallic and Plastic Piping

Connections between metallic and plastic piping are only allowed outside, underground, and with approved transition fittings.

3.4.5 Concealed Piping in Buildings

Do not use combinations of fittings (unions, tubing fittings, running threads, right- and left-hand couplings, bushings, and swing joints) to conceal piping within buildings.

3.4.5.1 Piping in Partitions

Locate concealed piping in hollow, rather than solid, partitions. Protect tubing passing through walls or partitions against physical damage both during and after construction, and provide appropriate safety markings and labels..

3.4.6 Aboveground Piping

Run aboveground piping as straight as practicable along the alignment and elevation indicated, with a minimum of joints, and separately supported from other piping system and equipment. Install exposed horizontal piping no farther than 6 inches from nearest parallel wall and at an elevation which prevents standing, sitting, or placement of objects on the piping.

3.4.7 Final Gas Connections

Unless otherwise specified, make final connections with rigid metallic pipe and fittings. Flexible connectors may be used for final connections to residential dryers. Flexible connectors may be used for final connections to gas utilization equipment. In addition to cautions listed in instructions required by ANSI standards for flexible connectors, insure that flexible connectors do not pass through equipment cabinet. Provide accessible gas shutoff valve and coupling for each gas equipment item.

3.4.8 Seismic Requirements

Support and brace piping and attached valves to resist seismic loads in conformance with ASCE 25 and as specified in UFC 3-310-04.

3.5 PIPE JOINTS

Design and install pipe joints to effectively sustain the longitudinal pull-out forces caused by contraction of the piping or superimposed loads.

3.5.1 Threaded Metallic Joints

Provide threaded joints in metallic pipe with tapered threads evenly cut and made with UL approved graphite joint sealing compound for gas service or tetrafluoroethylene tape applied to the male threads only. Threaded joints up to 1-1/2 inches in diameter may be made with approved tetrafluoroethylene tape. Threaded joints up to 2 inches in diameter may be made with approved joint sealing compound. After cutting and before threading, ream pipe and remove all burrs. Caulking of threaded joints to stop or prevent leaks is not permitted.

3.5.2 Welded Metallic Joints

Conform beveling, alignment, heat treatment, and inspection of welds to NFPA 54. Remove weld defects and make repairs to the weld, or remove the weld joints entirely and reweld. After filler metal has been removed from its original package, protect and store so that its characteristics or welding properties are not affected adversely. Do not use electrodes that have been wetted or have lost any of their coating.

3.5.3 Thermoplastic and Fiberglass Joints

a. Thermoplastic and Fiberglass: Conform jointing procedures to AGA XR0603. Do not make joints with solvent cement or heat of fusion between different kinds of plastics.

b. PE Fusion Welding Inspection: Visually inspect butt joints by comparing with, manufacturer's visual joint appearance chart. Inspect fusion joints for proper fused connection. Replace defective joints by cutting out defective joints or replacing fittings. Inspect, in conformance with API 570, 100 percent of all joints and re-inspect all corrections. Arrange with the pipe manufacturer's representative in the presence of the Contracting Officer to make first time inspection.

3.5.4 Flared Metallic Tubing Joints

Make flared joints in metallic tubing with special tools recommended by the tubing manufacturer. Use flared joints only in systems constructed from nonferrous pipe and tubing, when experience or tests have demonstrated that the joint is suitable for the conditions, and when adequate provisions are made in the design to prevent separation of the joints. Do not use metallic ball sleeve compression-type tubing fittings for tubing joints.

3.5.5 Solder or Brazed Joints

Make all joints in metallic tubing and fittings with materials and procedures recommended by the tubing supplier. Braze joints with material having a melting point above 1000 degrees F, containing no phosphorous.

3.5.6 Joining Thermoplastic or Fiberglass to Metallic Piping or Tubing

When compression type mechanical joints are used, provide gasket material in the fittings compatible with the plastic piping and with the gas in the system. Use an internal tubular rigid stiffener in conjunction with the fitting, flush with end of the pipe or tubing, extending at least to the outside end of the compression fitting when installed. Remove all rough or sharp edges from stiffener. Do not force fit stiffener in the plastic. Split tubular stiffeners are not allowed.

3.5.7 Press Connections

Make press connections in accordance with manufacturer's installation instructions using tools approved by the manufacturer. Fully insert the tubing into the fitting and then mark at the shoulder of the fitting. Check the fitting alignment against the mark on the tubing to assure the tubing is fully inserted before the joint is pressed.

3.6 PIPE SLEEVES

Provide pipes passing through concrete or masonry walls or concrete floors

or roofs with pipe sleeves fitted into place at the time of construction. Do not install sleeves in structural members except where indicated or approved. Make all rectangular and square openings as detailed. Extend each sleeve through its respective wall, floor or roof, and cut flush with each surface, except in mechanical room floors not located on grade where clamping flanges or riser pipe clamps are used. Extend sleeves in mechanical room floors above grade at least 4 inches above finish floor. Unless otherwise indicated, use sleeves large enough to provide a minimum clearance of 1/4 inch all around the pipe. Provide steel pipe for sleeves in bearing walls, waterproofing membrane floors, and wet areas . Provide sleeves in nonbearing walls, floors, or ceilings of steel pipe, galvanized sheet metal with lock-type longitudinal seam, or moisture-resistant fiber or plastic. For penetrations of fire walls, fire partitions and floors which are not on grade, seal the annular space between the pipe and sleeve with fire-stopping material and sealant that meet the requirement of Section 07 84 00 FIRESTOPPING.

3.7 PIPES PENETRATING WATERPROOFING MEMBRANES

Install pipes penetrating waterproofing membranes as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.8 FIRE SEAL

Fire seal all penetrations of fire rated partitions, walls and floors in accordance with Section 07 84 00 FIRESTOPPING.

3.9 ESCUTCHEONS

Provide escutcheons for all finished surfaces where gas piping passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms.

3.10 SPECIAL REQUIREMENTS

Provide drips, grading of the lines, freeze protection, and branch outlet locations as shown and conforming to the requirements of NFPA 54.

3.11 BUILDING STRUCTURE

Do not weaken any building structure by the installation of any gas piping. Do not cut or notch beams, joists or columns. Attach piping supports to metal decking. Do not attach supports to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

3.12 PIPING SYSTEM SUPPORTS

Support gas piping systems in buildings with pipe hooks, metal pipe straps, bands or hangers suitable for the size of piping or tubing. Do not support any gas piping system by other piping. Conform spacing of supports in gas piping and tubing installations to the requirements of NFPA 54. Conform the selection and application of supports in gas piping and tubing installations to the requirements of MSS SP-69. In the support of multiple pipe runs on a common base member, use a clip or clamp where each pipe crosses the base support member. Spacing of the base support members is not to exceed the hanger and support spacing required for any of the individual pipes in the multiple pipe run. Rigidly connect the clips or clamps to the common base member. Provide a clearance of 1/8 inch between

the pipe and clip or clamp for all piping which may be subjected to thermal expansion.

3.13 ELECTRICAL BONDING AND GROUNDING

Provide a gas piping system within the building which is electrically continuous and bonded to a grounding electrode as required by NFPA 70.

3.14 SHUTOFF VALVE

Install the main gas shutoff valve controlling the gas piping system to be easily accessible for operation, as indicated, protected from physical damage, and marked with a metal tag to clearly identify the piping system controlled.

3.15 CATHODIC PROTECTION

Provide cathodic protection for underground ferrous gas piping as specified in Section 26 42 14.00 10 CATHODIC PROTECTION SYSTEM (SACRIFICIAL ANODE).

3.16 TESTING

Submit test reports in booklet form tabulating test and measurements performed; dated after award of this contract, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements which are being certified. Test entire gas piping system to ensure that it is gastight prior to putting into service. Prior to testing, blow out the system, clean, and clear all foreign material. Test each joint with an approved gas detector, soap and water, or an equivalent nonflammable solution. Inspect and test each valve in conformance with API Std 598 and API Std 607. Complete testing before any work is covered, enclosed, or concealed, and perform with due regard for the safety of employees and the public during the test. Install bulkheads, anchorage and bracing suitably designed to resist test pressures if necessary, and as directed and or approved by the Contracting Officer. Do not use oxygen as a testing medium.

3.16.1 Pressure Tests

Submit test reports in booklet form tabulating test and measurements performed; dated after award of this contract, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements which are being certified. Before appliances are connected, test by filling the piping systems with air or an inert gas to withstand a minimum pressure of 3 pounds gauge for a period of not less than 10 minutes as specified in NFPA 54 without showing any drop in pressure. Do not use Oxygen for test. Measure pressure with a mercury manometer, slope gauge, or an equivalent device calibrated to be read in increments of not greater than 0.1 pound. Isolate the source of pressure before the pressure tests are made.

3.16.2 Test With Gas

Before turning on gas under pressure into any piping, close all openings from which gas can escape. Immediately after turning on the gas, check the piping system for leakage by using a laboratory-certified gas meter, an appliance orifice, a manometer, or equivalent device. Conform all testing to the requirements of NFPA 54. If leakage is recorded, shut off the gas supply, repair the leak , and repeat the tests until all leaks have been

stopped.

3.16.3 Purging

After testing is completed, and before connecting any appliances, fully purge all gas piping. Conform testing procedures to API RP 1110. Do not purge piping into the combustion chamber of an appliance. Do not purge the open end of piping systems into confined spaces or areas where there are ignition sources unless the safety precautions recommended in NFPA 54 are followed.

3.16.4 Labor, Materials and Equipment

Furnish all labor, materials and equipment necessary for conducting the testing and purging.

3.17 PIPE COLOR CODE MARKING

Provide color code marking of piping as specified in Section 09 90 00 PAINTS AND COATINGS, conforming to ASME A13.1.

-- End of Section --

SECTION 23 52 00.00 10

WATER AND STEAM HEATING; OIL, GAS OR BOTH; UP TO 20 MBTUH
10/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 801	(2001) Industrial Process/Power Generation Fans: Specification Guidelines

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 52.1	(1992) Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2006) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2004; Errata 2004) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.2	(1991) Brazing Procedure and Performance Qualification

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 2006) Pipe Threads, General Purpose (Inch)
ASME B16.11	(2005) Forged Fittings, Socket-Welding and Threaded
ASME B16.15	(2006) Cast Bronze Threaded Fittings Classes 125 and 250
ASME B16.18	(2001; R 2005) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.20	(1998; Addenda A 2000; R 2004) Metallic Gaskets for Pipe Flanges - Ring-Joint, Spiral Wound, and Jacketed
ASME B16.22	(2001; R 2005) Standard for Wrought Copper

	and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2006) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(2006) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.34	(2004) Valves - Flanged, Threaded and Welding End
ASME B16.39	(1998; R 2006) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.4	(2006) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.5	(2003) Standard for Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24
ASME B16.9	(2007) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.1	(2007; Addenda 2008) Power Piping
ASME B31.5	(2006) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2006) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IV	(2007) Boiler and Pressure Vessel Code; Section IV, Recommended Rules for the Care and Operation of Heating Boilers
ASME BPVC SEC IX	(2007; Addenda 2008) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2007; Addenda 2008) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage
ASME CSD-1	(2006) Control and Safety Devices for Automatically Fired Boilers

ASTM INTERNATIONAL (ASTM)

ASTM A 105/A 105M	(2005) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A 167	(1999; R 2004) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 183	(2003) Standard Specification for Carbon

	Steel Track Bolts and Nuts
ASTM A 193/A 193M	(2007) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 234/A 234M	(2007) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A 515/A 515M	(2003) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A 516/A 516M	(2006) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A 53/A 53M	(2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 536	(1984; R 2004) Standard Specification for Ductile Iron Castings
ASTM A 653/A 653M	(2008) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B 32	(2008) Standard Specification for Solder Metal
ASTM B 62	(2002) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B 75	(2002) Standard Specification for Seamless Copper Tube
ASTM B 813	(2000e1) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM B 828	(2002) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM B 88	(2003) Standard Specification for Seamless Copper Water Tube
ASTM B 88M	(2005) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM D 2000	(2008) Standard Classification System for Rubber Products in Automotive Applications
ASTM D 596	(2001; R 2006) Reporting Results of

Analysis of Water

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015 (1994; R 1995) Copper Tube Handbook

CSA AMERICA, INC. (CSA/AM)

CSA/AM Z21.13 (2005; A 2005) Gas-Fired Low-Pressure Steam and Hot Water Boilers

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds (2003) EJMA Standards

HYDRONICS INSTITUTE DIVISION OF GAMA (HYI)

HYI-005 (2004) I=B=R Ratings for Boilers, Baseboard Radiation and Finned Tube (Commercial)

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-110 (1996) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

MSS SP-25 (1998) Standard Marking System for Valves, Fittings, Flanges and Unions

MSS SP-58 (2002) Standard for Pipe Hangers and Supports - Materials, Design and Manufacture

MSS SP-69 (2003; R 2004) Standard for Pipe Hangers and Supports - Selection and Application

MSS SP-70 (2006) Standard for Cast Iron Gate Valves, Flanged and Threaded Ends

MSS SP-71 (2005) Standard for Gray Iron Swing Check Valves, Flanged and Threaded Ends

MSS SP-72 (1999) Standard for Ball Valves with Flanged or Butt-Welding Ends for General Service

MSS SP-73 (2003) Brazing Joints for Copper and Copper Alloy Pressure Fittings

MSS SP-78 (2005a) Cast Iron Plug Valves, Flanged and Threaded Ends

MSS SP-80 (2008) Bronze Gate, Globe, Angle and Check Valves

MSS SP-85 (2002) Standard for Cast Iron Globe & Angle Valves, Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2003) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2008) National Fuel Gas Code
NFPA 85	(2007) Boiler and Combustion Systems Hazards Code

UNDERWRITERS LABORATORIES (UL)

UL 1738	(1993; Rev thru Oct 2006) Venting Systems for Gas-Burning Appliances, Categories II, III and IV
UL 795	(2006) Commercial-Industrial Gas Heating Equipment
UL Gas&Oil Dir	(2008) Flammable and Combustible Liquids and Gases Equipment Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Piping Installation
Installation

Detail drawings consisting of equipment layout including installation details and electrical connection diagrams; combustion and safety control diagrams; ductwork layout showing the location of supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications; and piping layout showing the location of guides and anchors, the load imposed on each support or anchor (not required for radiant floor tubing), and typical support details. Drawings shall include any information required to demonstrate that the system has been coordinated and will properly function as a unit and shall show equipment relationship to other parts of the work, including clearances required for operation and maintenance.

SD-03 Product Data

Materials and Equipment

Manufacturer's catalog data shall be included with the detail drawings for the following items:

The data shall show model, size, options, etc., that are intended for consideration. Data submitted shall be adequate to demonstrate compliance with contract requirements. Data shall include manufacturer's written installation instructions and manufacturer's recommendations for operation and maintenance clearances for each item.

Boilers
Unit Heaters
Fuel Burning Equipment
Combustion Control Equipment
Pumps
Fittings and Accessories
Water Treatment System

Welding

A copy of qualified welding procedures, at least 2 weeks prior to the start of welding operations.

A list of names and identification symbols of qualified welders and welding operators, at least 2 weeks prior to the start of welding operations.

SD-06 Test Reports

Heating System Tests
Fuel System Tests

Test reports for the heating system tests and the fuel system test, upon completion of testing complete with results.

Water Treatment Testing; G

a. The water quality test report shall identify the chemical composition of the boiler water. The report shall include a comparison of the condition of the boiler water with the manufacturer's recommended conditions. Any required corrective action shall be documented within the report.

SD-07 Certificates

Continuous Emissions Monitoring

Written certification by the boiler manufacturer that each boiler furnished complies with Federal, state, and local regulations for emissions. The certification shall also include a description of applicable emission regulations. If any boiler is exempt from the emission regulations, the certification shall indicate the reason for the exemption.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

Six complete copies of the manual in bound 8 1/2 x 11 inch booklets. List step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and

normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Provide spare parts data for each different item of equipment. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replace on a routine basis.

List routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

A certified list of qualified permanent service organizations, which includes their addresses and qualifications, for support of the equipment. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3 GENERAL REQUIREMENTS

1.3.1 Standard Products

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market. Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products shall be supported by a service organization.

1.3.2 Asbestos Prohibition

Asbestos and asbestos-containing products shall not be used.

1.3.3 Nameplates

Each major component of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the equipment. Each pressure vessel shall have an approved ASME stamp.

1.3.4 Equipment Guards

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded in accordance with OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation

of a type specified. Catwalks, operating platforms, ladders, and guardrails shall be provided where shown and shall be constructed in accordance with Section 05 50 00 METAL: MISCELLANEOUS AND FABRICATIONS.

1.3.5 Verification of Dimensions

The Contractor shall become familiar with details of the work, verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work or ordering any materials.

1.3.6 Welding

Boilers and piping shall be welded and brazed in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests, and the tests shall be performed at the work site if practical. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. Structural members shall be welded in accordance with Section 05 05 23 WELDING, STRUCTURAL.

1.4 MANUFACTURER'S SERVICES

Services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified shall be provided. The representative shall supervise the installing, adjusting, and testing of the equipment.

1.5 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be protected from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

PART 2 PRODUCTS

2.1 BOILERS

Each boiler shall have the output capacity in British thermal units per hour (Btuh) as indicated when fired with the specified fuels. The boiler shall be furnished complete with the gas burning equipment, boiler fittings and trim, automatic controls, forced draft fan with burner assembly, electrical wiring, insulation, piping connections, and protective jacket. The boiler shall be completely assembled and tested at the manufacturer's plant. Boiler auxiliaries including fans, motors, drives, and similar equipment shall be provided with at least 10 percent excess capacity to allow for field variations in settings and to compensate for any unforeseen increases in pressure losses in appurtenant piping and ductwork. However, the boiler safety devices shall not be sized for a 10 percent excess capacity. The boiler and its accessories shall be designed and installed to permit ready accessibility for operation, maintenance, and service. Boilers shall be designed, constructed, and equipped in accordance with ASME BPVC SEC IV. Each boiler shall be of the condensing type and designed for water service as specified herein. The boiler capacity shall be based on the ratings shown in HYI-005 or as certified by the American Boiler Manufacturers Association, or American Gas Association.

2.1.1 Condensing Boiler

Each boiler shall be a self-contained packaged type, complete with accessories, mounted on a structural steel base or a steel base which is integral to the boiler shell. Each boiler shall conform to the commercial design used by the manufacturer and shall permit free thermal expansion without placing undue stress on any part of the boiler. Each boiler which experiences the formation of condensate within the flue gas shall be specifically designed for condensing application. Each boiler shall withstand the corrosive effects of condensate for each part which may be in contact with the condensate at all possible operating conditions. Each boiler shall be provided with a separate air intake, exhaust, and condensate drain. Each boiler shall be designed to withstand the water temperature differentials anticipated at the required operating conditions without experiencing any damage due to thermal shock.

2.1.2 Modular Configuration

Modular boilers shall be of the condensing type. Modular boilers shall have the capability of independent operation. Upon failure of any module, the remaining modules shall be capable of operating at their designed capacity. The size of the individual modules shall be as indicated.

2.2 FUEL BURNING EQUIPMENT

Boiler shall be designed to burn gas. Each boiler shall comply with Federal, state, and local emission regulations.

2.2.1 Burners

2.2.1.1 Gas and Combination Gas-Oil Fired Burners and Controls

Burners shall be UL approved mechanical draft burners with all air necessary for combustion supplied by a blower where the operation is coordinated with the burner. Burner shall be provided complete with fuel supply system in conformance with the following safety codes or standards:

a. Gas-fired units with inputs greater than 400,000 Btuh per combustion chamber shall conform to UL 795. Gas fired units less than 12,500,000 Btuh input shall conform to CSA/AM Z21.13. Single and multiple burner gas-fired units greater than or equal to 12,500,000 Btuh input shall conform to NFPA 85.

2.2.2 Draft Fans

Fans conforming to AMCA 801 forced-draft shall be furnished as an integral part of boiler design. Fans shall be centrifugal with backward-curved blades, radial-tip blades, or axial flow type. Each fan shall be sized for output volume and static pressure rating sufficient for pressure losses, excess air requirements at the burner, leakages, temperature, and elevation corrections for worst ambient conditions, all at full combustion to meet net-rated output at normal firing conditions, plus an overall excess air volume of 10 percent against a 20 percent static overpressure. Noise levels for fans shall not exceed 85 decibels in any octave band at a 3 foot station.

2.2.2.1 Draft Fan Control

Forced-draft centrifugal fans shall have inlet vane controls or shall have

variable speed control where indicated. Inlet vanes shall be suitable for use with combustion control equipment.

2.2.2.2 Draft Fan Drives

Fans shall be driven by electric motors. Electric motor shall be drip proof enclosure and shall be furnished with four auxiliary interlock contacts.

2.3 COMBUSTION CONTROL EQUIPMENT

Combustion control equipment shall be provided as a system by a single manufacturer. Field installed automatic combustion control system shall be installed in accordance with the manufacturer's recommendations and under the direct supervision of a representative of the control manufacturer. The boiler water temperature shall be controlled by a water temperature controller. The equipment shall operate electrically. On multiple boiler installations, each boiler unit shall have a completely independent system of controls responding to the load and to a plant master controller. If recording instruments are provided, a 1 year supply of ink and 400 blank charts for each recorder shall be furnished.

2.3.1 Electrical controls

Electrical control devices shall be rated at 120 or 24 volts and shall be connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.3.2 Water Temperature Controller

The controller shall be of sturdy construction and shall be protected against dust and dampness. The thermostatic element shall be inserted in a separable socket installed in the boiler return piping. Fixed position (on-off) and three position (high-low-off) controller shall operate on a 10 degree F differential over an adjustable temperature range of approximately 80 to 140 degrees F. Modulating controllers shall control the fuel burning equipment to maintain set boiler water temperature within 2 percent. Controller shall be furnished with necessary equipment to automatically adjust the setting to suit the outside weather conditions. The outside air reset controller shall be operated in such a manner that the operating temperatures required by the boiler manufacturer are not compromised.

2.3.3 Boiler Plant Master Controller

A boiler plant master controller, sensitive to a temperature transmitter in the return water header for the boiler shall be furnished to provide anticipatory signals to all boiler controllers. Boiler controllers shall react to anticipatory signals from the plant master controller as necessary in response to the boiler temperature indication to maintain the preset temperature. An automatic-manual switch shall be provided to allow the sequence of boiler loading to be varied to distribute equal firing time on all boilers in the plant. The plant master controller shall load the boilers one at a time as the plant load increases.

2.3.4 Boiler Combustion Controls and Positioners

a. Gas boiler units shall be provided with three position (high-low-off) or modulating combustion controls with gas pilot or spark ignition. Modulating controls shall be provided with a means for manually controlling the firing rate.

b. Modulating control function shall be accomplished using positioning type controls. Air flow ratio and fuel control valve shall be controlled by relative positions of operative levers on a jackshaft responding to a water temperature controller. Positioning type combustion control equipment shall include draft controls with synchronized fuel feed and combustion air supply controls and shall maintain the proper air/fuel ratio. The desired furnace draft shall be maintained within 0.01 inch of water column.

2.3.5 Combustion Safety Controls and Equipment

Combustion safety controls and equipment shall be UL listed, microprocessor-based distributed process controller. The system shall include mounting hardware, wiring and cables, and associated equipment. The controller shall be mounted completely wired, programmed, debugged, and tested to perform all of its functions. The controller shall process the signals for complete control and monitoring of the boiler. This shall include maintaining boiler status, starting and stopping all control functions, sequencing control functions and signaling alarm conditions. The program shall be documented and include cross references in description of coils and contacts. Microprocessor shall be able to perform self diagnostics and contain a message center to provide operator with status and failure mode information. Controllers for each boiler shall be mounted on a separate, free standing panel adjacent to the boiler or for packaged boilers on the boiler supporting structure. Control systems and safety devices for automatically fired boilers shall conform to ASME CSD-1. Electrical combustion and safety controls shall be rated at 120 volts, single phase, 60 Hz and shall be connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. A 4 inch diameter alarm bell shall be provided and shall be located where indicated or directed. The alarm bell shall ring when the boiler is shut down by any safety control or interlock. Indicating lights shall be provided on the control panel. A red light shall indicate flame failure, and a green light shall indicate that the main fuel valve is open. The following shutdown conditions shall require a manual reset before the boiler can automatically recycle:

a. Flame failure.

b. Failure to establish pilot flame.

c. Failure to establish main flame.

d. Low-water cutoff.

e. High temperature cutoff.

2.3.5.1 Low-water Cutoff

Low water cutoff shall be float actuated switch or electrically actuated probe type low-water cutoff. Float chamber shall be provided with a blow-down connection. Cutoff shall cause a safety shutdown and sound an alarm when the boiler water level drops below a safe minimum level. A safety shutdown due to low water shall require manual reset before operation can be resumed and shall prevent recycling of the burner. The cutoff shall be in strict accordance to the latest version of code, ASME CSD-1 Controls and Safety Devices for Automatically Fired Boilers.

a. Feedwater Regulator with Low-Water Cutoff: Regulator shall be an

approved design sized for the application. A regulator shall be provided for each boiler. The feeder shall be so arranged that water will be fed to the boiler automatically when the water level in the boiler drops below a preset point and will actuate the alarm bell when the water level reaches the low danger point. The boiler feeder shall be arranged so that the burner and forced-draft fan will stop whenever the water level drops below a preset danger point. The boiler feeder shall be constructed so that the feedwater valve and seat are isolated from the float chamber to prevent overheating of the feed water and precipitation of scale on either the valve or seat. Each float mechanism, valve, and seat shall be constructed of an approved, durable, corrosion-resistant steel alloy. Valve seats shall be removable and renewable. The regulator shall be equipped with a large, self-cleaning strainer. The drain valve on the regulator shall be the gate or other straight-through type.

b. Pump Controller with Low-Water Cutoff: Controller shall be a design approved by the boiler manufacturer. A pump controller shall be provided for each boiler which is used for space heating and process steam loads or long distribution lines. Pump controller shall control the operation of the burner, forced-draft fan, and pump. Pump controller and low-water cutoff shall have a float-operated mercury switch arranged to start and stop the pump at preset boiler water levels. If the water level in the boiler reaches the low danger point, a second mercury switch shall shut down the burner and actuate the alarm bell.

c. Supplementary Low-Water Cutoff: Supplementary low-water cutoff of the electrically operated probe type or float activated type shall be provided in addition to the low-water cutoff required above on each boiler. Supplementary low-water cutoff shall be mounted directly in the boiler shell and shall be set below the low-water cutoff required above.

2.3.5.2 Water Flow Interlock

Hot water boiler limit controls shall be provided to include protection for low boiler water flow and high boiler water temperature. The limit controls shall be interlocked with the combustion control system to effect boiler alarm and shutdown. The controls shall not allow boiler startup unless hot water flow is proven.

2.4 PUMPS

2.4.1 Hot Water and Boiler Circulating Pumps

Circulating pumps for hot water shall be electrically driven single-stage centrifugal type and have a capacity not less than indicated. Boiler circulating pumps shall be supported on a concrete foundation with a cast iron or structural steel base or by the piping on which installed and shall be closed-coupled shaft or flexible-coupled shaft. The boiler circulating pumps shall be horizontal split case or vertical split case type. The hot water circulating pumps shall be horizontal split case type. The pump shaft shall be constructed of corrosion-resistant alloy steel, sleeve bearings and glands of bronze designed to accommodate a mechanical seal, and the housing of close-grained cast iron. Pump seals shall be capable of withstanding 240 degrees F temperature without external cooling. The motor shall have sufficient power for the service required, shall be of a type

approved by the manufacturer of the pump, shall be suitable for the available electric service, and shall conform to the requirements of paragraph ELECTRICAL EQUIPMENT. Each pump suction and discharge connection shall be provided with a pressure gauge as specified. The boiler, and hot water circulating pump discharge heater shall be provided with a flow switch. Flow switch unit shall be a self-contained swinging vane type to indicate fluid flow. Switch shall be a SPDT with 120-volt, 15-ampere rating.

2.5 COLD WATER CONNECTIONS

Connections shall be provided which includes consecutively in line a strainer, reduced pressure principle backflow preventers, and water pressure regulator in that order in the direction of the flow. The reduced pressure principle backflow preventers shall be provided as indicated and in compliance with Section 22 00 00 PLUMBING, GENERAL PURPOSE. Cold water fill connections shall be made to the water supply system as indicated. Necessary pipe, fittings, and valves required for water connections between the boiler and cold water main shall be provided as shown. The pressure regulating valve shall be of a type that will not stick or allow pressure to build up on the low side. The valve shall be set to maintain a terminal pressure of approximately,lately 5 psi in excess of the static head on the system and shall operate within a 2 psi tolerance regardless of cold water supply piping pressure and without objectionable noise under any condition of operation.

2.6 UNIT HEATERS

Heaters shall be as specified below, and shall have a heating capacity not in excess of 125 percent of the capacity indicated. Noise level of each unit heater for areas noted shall not exceed the criteria indicated.

2.6.1 Propeller Fan Heaters

Heaters shall be designed for suspension and arranged for discharge of air as indicated. Casings shall be not less than 20 gauge black steel and finished with lacquer or enamel. Suitable deflectors shall be provided to assure proper air and heat penetration capacity at floor level based on established design temperature. Suspension from heating pipes will not be permitted. Fans for vertical discharge type heaters shall operate at speeds not in excess of 1,200 rpm, except that units with 80,000 Btu output capacity or less may operate at speeds up to 1,800 rpm. Horizontal discharge type unit heaters shall have discharge or face velocities not in excess of the following:

Unit Capacity, cfm	Face Velocity, fpm
Up to 1,000	800
1,001 to 3,000	900
3,001 and over	1,000

2.6.2 Centrifugal Fan Heaters

Heaters shall be arranged for floor or ceiling mounting as indicated. Heating elements and fans shall be housed in steel cabinets of sectionalized steel plates or reinforced with angle-iron frames. Cabinets shall be constructed of not lighter than 18 gauge black steel. Each unit heater shall be provided with a means of diffusing and distributing the

air. Fans shall be mounted on a common shaft, with one fan to each air outlet. Fan shaft shall be equipped with self-aligning ball, roller, or sleeve bearings and accessible means of lubrication. Fan shaft may be either directly connected to the driving motor or indirectly connected by adjustable V-belt drive rated at 150 percent of motor capacity. All fans in any one unit heater shall be the same size.

2.6.3 Heating Elements

Heating coils and radiating fins shall be of suitable nonferrous alloy with brazed fittings at each end for connecting to external piping. The heating elements shall be free to expand or contract without developing leaks and shall be properly pitched for drainage. The elements shall be tested under a hydrostatic pressure of 200 psig and a certified report of the test shall be submitted to the Contracting Officer. Heating coils shall be as specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM for types indicated. Coils shall be suitable for use with water up to 250 degrees F.

2.6.4 Motors

Motors shall be provided with NEMA 250 general purpose enclosure. Motors and motor controls shall otherwise be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.6.5 Motor Switches

Motors shall be provided with manual selection switches with "Off," and "Automatic" positions and shall be equipped with thermal overload protection.

2.6.6 Controls

Controls shall be provided as specified in Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS.

2.7 AIR HANDLING UNITS

Air handling units and associated equipment shall be in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.8 FITTINGS AND ACCESSORIES

Boiler fittings and accessories shall be installed with each boiler in accordance with ASME BPVC SEC IV, unless otherwise specified.

2.8.1 Continuous Emissions Monitoring

2.8.1.1 Wiring

The CEMS equipment shall be provided with plug-in prefabricated cable for interconnection between components. Power supply to the equipment shall be 2-wire, 120 volt nominal or less, 60 Hz, with one side grounded. Electrical devices shall be connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.8.2 Direct Vents

Direct venting shall be used for condensing type boilers. Both the air

intake and exhaust vents shall be sized and located as indicated on the drawings and as recommended by the boiler manufacturer.

2.8.2.1 Exhaust Vent

The exhaust vent piping shall be constructed of stainless steel conforming to UL 1738 and the boiler manufacturer's recommendations. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. The exhaust vent shall be suitable for the maximum anticipated boiler exhaust temperature and shall withstand the corrosive effects of the condensate. A 0.3125 inch diameter hole shall be provided in the stack not greater than 6 inches from the boiler flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the boiler room when samples are not being taken. Each exhaust stack shall be provided complete with bird screen.

2.8.3 Expansion Tank

The hot water pressurization system shall include a diaphragm-type expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The only air in the system shall be the permanent sealed-in air cushion contained in the diaphragm-type tank. The sizes shall be as indicated. The expansion tank shall be welded steel, constructed, tested, and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 125 psi and precharged to the minimum operating pressure. The tank's air chamber shall be fitted with an air charging valve and pressure gauge. The tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The tank shall have lifting rings and a drain connection. All components shall be suitable for a maximum operating temperature of 250 degrees F.

2.8.4 Air Separator

External air separation tank shall be steel, constructed, tested and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 125 psi. The capacity of the air separation tank indicated is minimum.

2.8.5 Filters

Filters shall conform to ASHRAE 52.1.

2.8.6 Steel Sheets

2.8.6.1 Galvanized Steel

Galvanized steel shall be ASTM A 653/A 653M.

2.8.6.2 Uncoated Steel

Uncoated steel shall be composition, condition, and finish best suited to the intended use.

2.8.7 Gaskets

Gaskets shall be nonasbestos material in accordance with ASME B16.20, full

face or self-centering type. The gaskets shall be of the spiral wound type with graphite filler material.

2.8.8 Steel Pipe and Fittings

2.8.8.1 Steel Pipe

Steel pipe shall be ASTM A 53/A 53M, Type E or S, Grade A or B, black steel, standard weight.

2.8.8.2 Steel Pipe Fittings

Fittings shall have the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently identify the manufacturer.

2.8.8.3 Steel Flanges

Flanged fittings including flanges, bolts, nuts, bolt patterns, etc. shall be in accordance with ASME B16.5 class 150 and shall have the manufacturers trademark affixed in accordance with MSS SP-25. Flange material shall conform to ASTM A 105/A 105M. Flanges for high temperature water systems shall be serrated or raised-face type. Blind flange material shall conform to ASTM A 516/A 516M cold service and ASTM A 515/A 515M for hot service. Bolts shall be high strength or intermediate strength with material conforming to ASTM A 193/A 193M.

2.8.8.4 Welded Fittings

Welded fittings shall conform to ASTM A 234/A 234M with WPA marking. Buttwelded fittings shall conform to ASME B16.9, and socket-welded fittings shall conform to ASME B16.11.

2.8.8.5 Cast-Iron Fittings

Fittings shall be ASME B16.4, Class 125, type required to match connecting piping.

2.8.8.6 Malleable-Iron Fittings

Fittings shall be ASME B16.3, type as required to match connecting piping.

2.8.8.7 Unions

Unions shall be ASME B16.39, Class 150.

2.8.8.8 Threads

Pipe threads shall conform to ASME B1.20.1.

2.8.8.9 Grooved Mechanical fittings

Joints and fittings shall be designed for not less than 125 psig service and shall be the product of the same manufacturer. Fitting and coupling houses shall be ductile iron conforming to ASTM A 536. Gaskets shall be molded synthetic rubber with central cavity, pressure responsive configuration and shall conform to ASTM D 2000 for circulating medium up to 230 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A 183.

2.8.9 Copper Tubing and Fittings

2.8.9.1 Copper Tubing

Tubing shall be ASTM B 88, ASTM B 88M, Type K or L. Adapters for copper tubing shall be brass or bronze for brazed fittings.

2.8.9.2 Solder-Joint Pressure Fittings

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B 75. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18 and ASTM B 828.

2.8.9.3 Flared Fittings

Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B 62.

2.8.9.4 Adapters

Adapters may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used.

2.8.9.5 Threaded Fittings

Cast bronze threaded fittings shall conform to ASME B16.15.

2.8.9.6 Brazing Material

Brazing material shall conform to AWS A5.8/A5.8M.

2.8.9.7 Brazing Flux

Flux shall be in paste or liquid form appropriate for use with brazing material. Flux shall be as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides, and contain fluorides. Silver brazing materials shall be in accordance with AWS A5.8/A5.8M.

2.8.9.8 Solder Material

Solder metal shall conform to ASTM B 32 95-5 tin-antimony.

2.8.9.9 Solder Flux

Flux shall be either liquid or paste form, non-corrosive and conform to ASTM B 813.

2.8.9.10 Grooved Mechanical Fittings

Joints and fittings shall be designed for not less than 125 psig service and shall be the product of the same manufacturer. Fitting and coupling houses shall be ductile iron conforming to ASTM A 536. Gaskets shall be molded synthetic rubber with central cavity, pressure responsible configuration and shall conform to ASTM D 2000, for circulating medium up to 230 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A 183.

2.8.10 Dielectric Waterways and Flanges

Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

2.8.11 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for 125 psi or 150 psi service. Connectors shall be installed where indicated. The flexible section shall be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. Materials used and the configuration shall be suitable for the pressure, vacuum, and temperature medium. The flexible section shall be suitable for service intended and may have threaded, welded, soldered, flanged, or socket ends. Flanged assemblies shall be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Covers to protect the bellows shall be provided where indicated.

2.8.12 Pipe Supports

Pipe supports shall conform to MSS SP-58 and MSS SP-69.

2.8.13 Pipe Expansion

2.8.13.1 Expansion Loops

Expansion loops and offsets shall provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. The loops and offsets shall be cold-sprung and installed where indicated. Pipe guides and anchors shall be provided as indicated.

2.8.13.2 Expansion Joints

Expansion joints shall provide for either single or double slip of the connected pipes, as required or indicated, and for not less than the transverse indicated. The joints shall be designed for a hot water working pressure not less than 125 psig and shall be in accordance with applicable requirements of EJMA Stds and ASME B31.1. End connection shall be flanged. Anchor bases or support bases shall be provided as indicated or required. Sliding surfaces and water wetted surfaces shall be chromium plated or fabricated of corrosion resistant steel. Initial setting shall be made in accordance with the manufacturer's recommendations to compensate for an ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer, but in any case shall not be more than 5 feet from expansion joint, except in lines 4 inches or smaller guides shall be installed not more than 2 feet from the joint. Service outlets shall be provided where indicated.

a. Bellows-type joints shall be flexible, guided expansion joints.

The expansion element shall be stabilized corrosion resistant steel. Bellows-type expansion joints shall conform to the applicable requirements of EJMA Stds and ASME B31.1 with internal lines. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint. The joints shall be designed for the working temperature and pressure suitable for the application but shall not be less than 150 psig.

b. Flexible ball joints shall be constructed of alloys as appropriate for the service intended. The joints shall be threaded, grooved, flanged, or welded end as required and shall be capable of absorbing the normal operating axial, lateral, or angular movements or combination thereof. Balls and sockets shall be polished, chromium-plated when materials are not of corrosion-resistant steel. The ball type joint shall be designed and constructed in accordance with ASME B31.1 and EJMA Stds. Flanges shall conform to the diameter and drilling of ASME B16.5. Molded gaskets shall be suitable for the service intended.

c. Slip type expansion joints shall be EJMA Stds and ASME B31.1, Class 1 or 2. Type II joints shall be suitable for repacking under full line pressure.

2.8.14 Valves

Valves shall be Class 125 and shall be suitable for the application. Grooved ends per AWWA C606 may be used for water service only. Valves in nonboiler external piping shall meet the material, fabrication and operating requirements of ASME B31.1. The connection type of all valves shall match the same type of connection required for the piping on which installed.

2.8.14.1 Gate Valves

Gate valves 2-1/2 inches and smaller shall conform to MSS SP-80 bronze rising stem, threaded, solder, or flanged ends. Gate valves 3 inches and larger shall conform to MSS SP-70 cast iron bronze trim, outside screw and yoke, flanged, or threaded ends.

2.8.14.2 Globe Valves

Globe valves 2-1/2 inches and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends. Globe valves 3 inches and larger shall conform to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

2.8.14.3 Check Valves

Check valves 2-1/2 inches and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends. Check valves 3 inches and larger shall conform to MSS SP-71, cast iron, bronze trim, flanged, or threaded ends.

2.8.14.4 Angle Valves

Angle valves 2-1/2 inches and smaller shall conform to MSS SP-80 bronze, threaded, soldered, or flanged ends. Angle valves 3 inches and larger shall conform to MSS SP-85, cast iron, bronze trim, flanged, or threaded

ends.

2.8.14.5 Ball Valves

Ball valves 1/2 inch and larger shall conform to MSS SP-72 or MSS SP-110, ductile iron or bronze, threaded, soldered, or flanged ends.

2.8.14.6 Plug Valves

Plug valves 2 inch and larger shall conform to MSS SP-78. Plug valves smaller than 2 inch shall conform to ASME B16.34.

2.8.14.7 Grooved End Valves

Valves with grooved ends per AWWA C606 may be used if the valve manufacturer certifies that their performance meets the requirements of the standards indicated for each type of valve.

2.8.14.8 Balancing Valves

Balancing valves shall have meter connections with positive shutoff valves. An integral pointer shall register the degree of valve opening. Valves shall be calibrated so that flow rate can be determined when valve opening in degrees and pressure differential across valve is known. Each balancing valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation. Valves shall be suitable for 250 degrees F temperature and working pressure of the pipe in which installed. Valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential. One portable differential meter shall be furnished. The meter suitable for the operating pressure specified shall be complete with hoses, vent, and shutoff valves, and carrying case. In lieu of the balancing valve with integral metering connections, a ball valve or plug valve with a separately installed orifice plate or venturi tube may be used for balancing.

2.8.14.9 Automatic Flow Control Valves

In lieu of the specified balancing valves, automatic flow control valves may be provided to maintain constant flow and shall be designed to be sensitive to pressure differential across the valve to provide the required opening. Valves shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Valves shall control the flow within 5 percent of the tag rating. Valves shall be suitable for the maximum operating pressure of 125 psi or 150 percent of the system operating pressure, whichever is greater. Where the available system pressure is not adequate to provide the minimum pressure differential that still allows flow control, the system pump head capability shall be increased. Valves shall be suitable for 250 degrees F temperature service. Valve materials shall be same as specified for the heating system check, globe, angle, and gate valves. Valve operator shall be the electric motor type or pneumatic type as applicable. Valve operator shall be capable of positive shutoff against the system pump head. Valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential across the automatic flow control valve.

A portable meter shall be provided with accessory kit as recommended for the project by the automatic valve manufacturer.

2.8.14.10 Butterfly Valves

Butterfly valves shall be 2-flange type or lug wafer type, and shall be bubbletight at 150 psig. Valve bodies shall be cast iron, malleable iron, or steel. ASTM A 167, Type 404 or Type 316, corrosion resisting steel stems, bronze, or corrosion resisting steel discs, and synthetic rubber seats shall be provided. Valves smaller than 8 inches shall have throttling handles with a minimum of seven locking positions. Valves 8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators. Valves in insulated lines shall have extended neck to accommodate insulation thickness.

2.8.14.11 Drain valves

Drain valves shall be provided at each drain point of blowdown as recommended by the boiler manufacturer. Piping shall conform to ASME BPVC SEC IVand ASTM A 53/A 53M.

2.8.14.12 Safety Valves

Safety valves shall have steel bodies and shall be equipped with corrosion-resistant trim and valve seats. The valves shall be properly guided and shall be positive closing so that no leakage can occur. Adjustment of the desired back-pressure shall cover the range between 2 and 10 psig. The adjustment shall be made externally, and any shafts extending through the valve body shall be provided with adjustable stuffing boxes having renewable packing. Boiler safety valves of proper size and of the required number, in accordance with ASME BPVC SEC IV, shall be installed so that the discharge will be through piping extended to a location as indicated. Each discharge pipe for hot water service shall be pitched away from the valve seat.

2.8.15 Strainers

Basket and "Y" type strainers shall be the same size as the pipelines in which they are installed. The strainer bodies shall be heavy and durable, fabricated of cast iron, and shall have bottoms drilled and tapped with a gate valve attached for blowdown purposes. Strainers shall be designed for 125 psig service and 250 degrees F. The bodies shall have arrows clearly cast on the sides indicating the direction of flow. Each strainer shall be equipped with an easily removable cover and sediment screen. The screen shall be made of 22 gauge thick brass sheet monel corrosion-resistant steel with small perforations numbering not less than 400/square inch to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

2.8.16 Pressure Gauges

Gauges shall conform to ASME B40.100 and shall be provided with throttling type needle valve or a pulsation dampener and shutoff valve. Minimum dial size shall be 3-1/2 inches. A pressure gauge shall be provided for each boiler in a visible location on the boiler. Pressure gauges shall be provided with readings in psi. Pressure gauges shall have an indicating pressure range that is related to the operating pressure of the fluid in

accordance with the following table:

Operating Pressure (kPA)	Pressure Range (kPA)
14-104	0-210 (retard)
Operating Pressure (psi)	Pressure Range (psi)
2-15	0-30 (retard)

2.8.17 Thermometers

Thermometers shall be provided with wells and separable corrosion-resistant steel sockets. Mercury shall not be used in thermometers. Thermometers for inlet water and outlet water for each hot water boiler shall be provided in a visible location on the boiler. Thermometers shall have brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a minimum 9 inch scale. The operating range of the thermometers shall be 32-212 degrees F. The thermometers shall be provided with readings in degrees F.

2.8.18 Air Vents

2.8.18.1 Manual Air Vents

Manual air vents shall be brass or bronze valves or cocks suitable for the pressure rating of the piping system and furnished with threaded plugs or caps.

2.8.18.2 Automatic Air Vents

Automatic air vents shall be 3/4 inch quick-venting float and vacuum air valves. Each air vent valve shall have a large port permitting the expulsion of the air without developing excessive back pressure, a noncollapsible metal float which will close the valve and prevent the loss of water from the system, an air seal that will effectively close and prevent the re-entry of air into the system when subatmospheric pressures prevail therein, and a thermostatic member that will close the port against the passage of steam from the system. The name of the manufacturer shall be clearly stamped on the outside of each valve. The air vent valve shall be suitable for the pressure rating of the piping system.

2.9 ELECTRICAL EQUIPMENT

Electric motor-driven equipment shall be provided complete with motors, motor starters, and necessary control devices. Electrical equipment, motor control devices, motor efficiencies and wiring shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Motors which are not an integral part of a packaged boiler shall be rated for high efficiency service. Motors which are an integral part of the packaged boiler shall be the highest efficiency available by the manufacturer of the packaged boiler. Motor starters shall be provided complete with properly sized thermal overload protections and other appurtenances necessary for the motor control specified. Starters shall be furnished in general purpose enclosures. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices but not shown shall be provided.

2.9.1 Motor Ratings

Motors shall be suitable for the voltage and frequency provided. Motors 1/2 hp and larger shall be three-phase, unless otherwise indicated. Motors shall be of sufficient capacity to drive the equipment at the specified capacity without exceeding the nameplate rating on the motor.

2.9.2 Motor Controls

Motor controllers shall be provided complete with properly sized thermal overload protection. Manual or automatic control and protective or signal devices required for the operation specified and any wiring required to such devices shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Solid state variable speed controllers shall be utilized for fractional through 10 hp ratings. Adjustable frequency drives shall be used for larger motors.

2.10 INSULATION

Shop and field-applied insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.11 TOOLS

Special tools shall be furnished. Special tools shall include uncommon tools necessary for the operation and maintenance of boilers, burners, pumps, fans, controls, meters, special piping systems, and other equipment. Small hand tools shall be furnished within a suitable cabinet, mounted where directed.

2.12 BOILER WATER TREATMENT

The water treatment system shall be capable of feeding chemicals and bleeding the system to prevent corrosion and scale within the boiler and piping distribution system. The water shall be treated to maintain the conditions recommended by the boiler manufacturer. Chemicals shall meet required federal, state, and local environmental regulations for the treatment of boilers and discharge to the sanitary sewer. The services of a company regularly engaged in the treatment of boilers shall be used to determine the correct chemicals and concentrations required for water treatment. The company shall maintain the chemical treatment and provide all chemicals required for a period of 1 year from the date of occupancy. Filming amines and proprietary chemicals shall not be used. The water treatment chemicals shall remain stable throughout the operating temperature range of the system and shall be compatible with pump seals and other elements of the system.

2.12.1 Boiler Water Limits

The boiler manufacturer shall be consulted for the determination of the boiler water chemical composition limits. The boiler water limits shall be as follows unless dictated differently by the boiler manufacturer's recommendations:

Causticity	20-200 ppm
Total Alkalinity (CACO3)	900-1200 ppm
Phosphate	30-60 ppm

Tanin	Medium
Dissolved Solids	3000-5000 ppm
Suspended Solids	300 ppm Max
Sodium Sulfite	20-40 ppm Max
Silica	Less than 150 ppm
Dissolved Oxygen	Less than 7 ppm
Iron	10 ppm
pH (Condensate)	7 - 8
Sodium Sulfite	20-40 ppm
Hardness	Less than 2 ppm
pH	9.3 - 9.9

2.12.2 Chemical Feed Pumps

One pump shall be provided for each chemical feed tank. The chemical feed pumps shall be positive displacement diaphragm type. The capacity of the pumps shall be adjustable from 0 to 100 percent while in operation. The discharge pressure of the pumps shall be not less than 1.5 times the pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge.

2.12.3 Tanks

The tanks shall be constructed of high density polyethylene with a hinged cover. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation. A level indicating device shall be included with each tank. An electric agitator shall be provided for each tank.

2.12.4 Injection Assemblies

An injection assembly shall be provided at each chemical injection point located along the boiler piping as indicated. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the piping. Each assembly shall include a shutoff valve and check valve at the point of entrance into the water line.

2.12.5 Water Meter

The water meter shall be provided with an electric contacting register and remote accumulative counter. The meter shall be installed within the makeup water line, as indicated.

2.12.6 Water Treatment Control Panel

The control panel shall be a NEMA 12, single door, wall-mounted box conforming with NEMA 250. The panel shall be constructed of stainless steel with a hinged door and lock. The panel shall contain, as a minimum, the following functions identified with a laminated plastic nameplate:

a. Main power switch and indicating light

b. MAN-OFF-AUTO selector switch

c. Indicating lamp for blow down

d. Indicating lamp for each chemical feed pump

e. Indicating lamp for the water softener

2.12.7 Sequence of Operation

The flow rate of chemical addition shall be based upon metering the makeup water. The boiler shall be provided with automatic blowdown based upon conductivity or boiler load. The required rate of chemical feed and boiler blowdown shall be determined by the water treatment company.

2.12.8 Chemical Shot Feeder

A shot feeder shall be provided as indicated. Size and capacity of feeder shall be based upon local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.12.9 Chemical Piping

The piping and fittings shall be constructed of schedule 80 PVC.

2.12.10 Test Kits

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided.

PART 3 EXECUTION

3.1 ERECTION OF BOILER AND AUXILIARY EQUIPMENT

Boiler and auxiliary equipment shall be installed in accordance with manufacturer's written instructions. Proper provision shall be made for expansion and contraction between boiler foundation and floor. This joint shall be packed with suitable nonasbestos rope and filled with suitable compound that will not become soft at a temperature of 100 degrees F. Boilers and firing equipment shall be supported from the foundations by structural steel completely independent of all brickwork. Boiler supports shall permit free expansion and contraction of each portion of the boiler without placing undue stress on any part of the boiler or setting. Boiler breeching shall be as indicated with full provision for expansion and contraction between all interconnected components.

3.2 PIPING INSTALLATION

Unless otherwise specified, nonboiler external pipe and fittings shall conform to the requirements of ASME B31.1. Pipe installed shall be cut accurately to suit field conditions, shall be installed without springing or forcing, and shall properly clear windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted. Pipes shall be free of burrs, oil, grease and other foreign material and shall be installed to permit free expansion and contraction without damaging the building structure, pipe, pipe joints, or pipe supports. Changes in direction shall be made with fittings, except that bending of pipe 4 inches and smaller will be permitted provided a pipe bender is used and wide sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. Vent pipes shall be carried through the roof as directed and shall be properly flashed. Unless otherwise indicated, horizontal supply mains shall pitch down in the direction of

flow with a grade of not less than 1 inch in 40 feet. Open ends of pipelines and equipment shall be properly capped or plugged during installation to keep dirt or other foreign materials out of the systems. Pipe not otherwise specified shall be uncoated. Unless otherwise specified or shown, final connections to equipment shall be made with malleable-iron unions for steel pipe 2-1/2 inches or less in diameter and with flanges for pipe 3 inches or more in diameter. Unions for copper pipe or tubing shall be brass or bronze. Reducing fittings shall be used for changes in pipe sizes. In horizontal hot water lines, reducing fittings shall be eccentric type to maintain the top of the lines at the same level to prevent air binding.

3.2.1 Hot Water Piping and Fittings

Pipe shall be black steel or copper tubing. Fittings for steel piping shall be black malleable iron or cast iron to suit piping. Fittings adjacent to valves shall suit valve material. Grooved mechanical fittings will not be allowed for water temperatures above 230 degrees F.

3.2.2 Vent Piping and Fittings

Vent piping shall be black steel. Fittings shall be black malleable iron or cast iron to suit piping.

3.2.3 Gauge Piping

Piping shall be copper tubing.

3.2.4 Joints

Joints between sections of steel pipe and between steel pipe and fittings shall be threaded, grooved, flanged or welded as indicated or specified. Except as otherwise specified, fittings 1 inch and smaller shall be threaded; fittings 1-1/4 inches and up to but not including 3 inches shall be either threaded, grooved, or welded; and fittings 3 inches and larger shall be either flanged, grooved, or welded. Pipe and fittings 1-1/4 inches and larger installed in inaccessible conduit or trenches beneath concrete floor slabs shall be welded. Connections to equipment shall be made with black malleable-iron unions for pipe 2-1/2 inches or smaller in diameter and with flanges for pipe 3 inchesinches or larger in diameter. Joints between sections of copper tubing or pipe shall be flared, soldered, or brazed.

3.2.4.1 Threaded Joints

Threaded joints shall be made with tapered threads properly cut and shall be made perfectly tight with a stiff mixture of graphite and oil or with polytetrafluoroethylene tape applied to the male threads only and in no case to the fittings.

3.2.4.2 Welded Joints

Welded joints shall be in accordance with paragraph GENERAL REQUIREMENTS unless otherwise specified. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connections may be made with either welding tees or forged branch outlet fittings, either being acceptable without size limitation. Branch outlet fittings, where used, shall be forged, flared for improved flow

characteristics where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength. Socket weld joints shall be assembled so that the space between the end of the pipe and the bottom of the socket is no less than 1/16 inch and no more than 1/8 inch.

3.2.4.3 Grooved Mechanical Joints

Grooved mechanical joints may be provided for hot water systems in lieu of unions, welded, flanged, or screwed piping connections in low temperature hot water systems where the temperature of the circulating medium does not exceed 230 degrees F. Grooves shall be prepared according to the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations. Mechanical joints shall use rigid mechanical pipe couplings, except at equipment connections. At equipment connections, flexible couplings may be used. Coupling shall be of the bolted type for use with grooved end pipes, fittings, valves, and strainers. Couplings shall be self-centering and shall engage in a watertight couple.

3.2.4.4 Flared and Brazed Copper Pipe and Tubing

Tubing shall be cut square, and burrs shall be removed. Both inside of fittings and outside of tubing shall be cleaned thoroughly with sand cloth or steel wire brush before brazing. Annealing of fittings and hard-drawn tubing shall not occur when making connections. Installation shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Brazed joints shall be made in conformance with AWS B2.2, MSS SP-73, and CDA A4015 with flux. Copper-to-copper joints shall include the use of copper-phosphorous or copper-phosphorous-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorous, copper-phosphorous-silver or a silver brazing filler metal. Joints for flared fittings shall be of the compression pattern. Swing joints or offsets shall be provided in all branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing. Flared or brazed copper tubing to pipe adapters shall be provided where necessary for joining threaded pipe to copper tubing.

3.2.4.5 Soldered Joints

Soldered joints shall be made with flux and are only acceptable for lines 2 inches and smaller. Soldered joints shall conform to ASME B31.5 and CDA A4015.

3.2.4.6 Copper Tube Extracted Joint

An extruded mechanical tee joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three

times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. The branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Extracted joints shall be brazed using a copper phosphorous classification brazing filler metal. Soldered joints will not be permitted.

3.2.5 Flanges and Unions

Flanges shall be faced true, provided with 1/16 inch thick gaskets, and made square and tight. Where steel flanges mate with cast-iron flanged fittings, valves, or equipment, they shall be provided with flat faces and full face gaskets. Union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Dielectric pipe unions shall be provided between ferrous and nonferrous piping to prevent galvanic corrosion. The dielectric unions shall have metal connections on both ends. The ends shall be threaded, flanged, or brazed to match adjacent piping. The metal parts of the union shall be separated so that the electrical current is below 1 percent of the galvanic current which would exist upon metal-to-metal contact. Gaskets, flanges, and unions shall be installed in accordance with manufacturer's recommendations.

3.2.6 Branch Connections

3.2.6.1 Branch Connections for Hot Water Systems

Branches from the main shall pitch up or down as shown to prevent air entrapment. Connections shall ensure unrestricted circulation, eliminate air pockets, and permit complete drainage of the system. Branches shall pitch with a grade of not less than 1 inch in 10 feet. When indicated, special flow fittings shall be installed on the mains to bypass portions of the water through each radiator. Special flow fittings shall be standard catalog products and shall be installed as recommended by the manufacturer.

3.2.7 Flared, Brazed, and Soldered Copper Pipe and Tubing

Copper tubing shall be flared, brazed, or soldered. Tubing shall be cut square, and burrs shall be removed. Both inside of fittings and outside of tubing shall be cleaned thoroughly with sand cloth or steel wire brush before brazing. Annealing of fittings and hard-drawn tubing shall not occur when making connections. Installation shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints for flared fittings shall be of the compression pattern. Swing joints or offsets shall be provided on branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing. Pipe adapters shall be provided where necessary for joining threaded pipe to copper tubing. Brazed joints shall be made in conformance with MSS SP-73, and CDA A4015. Copper-to-copper joints shall include the use of copper-phosphorous or copper-phosphorous-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorous, copper-phosphorous-silver, or a silver brazing filler metal. Soldered joints shall be made with flux and are only acceptable for lines 2 inches or smaller. Soldered joints shall conform to ASME B31.5 and shall be in accordance with CDA A4015.

3.2.8 Copper Tube Extracted Joint

An extracted mechanical tee joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. The branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Extracted joints shall be brazed using a copper phosphorous classification brazing filler metal. Soldered joints will not be permitted.

3.2.9 Supports

Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. Threaded rods which are used for support shall not be formed or bent. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

3.2.9.1 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein.

a. Types 5, 12, and 26 shall not be used.

b. Type 3 shall not be used on insulated pipe which has a vapor barrier. Type 3 may be used on insulated pipe that does not have a vapor barrier if clamped directly to the pipe, if the clamp bottom does not extend through the insulation, and if the top clamp attachment does not contact the insulation during pipe movement.

c. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.

d. Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices furnished by the manufacturer. Field fabricated C-clamp bodies or retaining devices are not acceptable.

e. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

f. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

g. Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves.

h. Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 15 feet, not more than 8 feet from end of risers, and at vent terminations.

i. Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

(1) Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 4 inches and larger, a Type 39 saddle may be welded to the pipe and freely rested on a steel plate. On piping under 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rested on a steel slide plate.

(2) Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide shall include a pipe cradle welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 4 inches or by an amount adequate for the insulation, whichever is greater.

j. Except for Type 3, pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation.

k. Piping in trenches shall be supported as indicated.

l. Structural steel attachments and brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material and installation shall be as specified under Section 05 12 00 STRUCTURAL STEEL. Pipe hanger loads suspended from steel joist between panel points shall not exceed 50 pounds. Loads exceeding 50 pounds shall be suspended from panel points.

3.2.9.2 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support member shall not exceed the hanger and support spacing required for any individual pipe in the multiple pipe run. The clips or clamps shall be rigidly attached to the common base member. A clearance of 1/8 inch shall be provided between the pipe insulation and the clip or clamp for piping which may be subjected to thermal expansion.

3.2.10 Anchors

Anchors shall be provided where necessary to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results, using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline.

3.2.11 Valves

Valves shall be installed where indicated, specified, and required for functioning and servicing of the systems. Valves shall be safely accessible. Swing check valves shall be installed upright in horizontal lines and in vertical lines only when flow is in the upward direction. Gate and globe valves shall be installed with stems horizontal or above. Valves to be brazed shall be disassembled prior to brazing and all packing removed. After brazing, the valves shall be allowed to cool before reassembling.

3.2.12 Pipe Sleeves

Pipe passing through concrete or masonry walls or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. A waterproofing clamping flange shall be installed as indicated where membranes are involved. Sleeves shall not be installed in structural members except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective wall, floor, or roof. Sleeves through walls shall be cut flush with wall surface. Sleeves through floors shall extend above top surface of floor a sufficient distance to allow proper flashing or finishing. Sleeves through roofs shall extend above the top surface of roof at least 6 inches for proper flashing or finishing. Unless otherwise indicated, sleeves shall be sized to provide a minimum clearance of 1/4 inch between bare pipe and sleeves or between jacket over insulation and sleeves. Sleeves in waterproofing membrane floors, bearing walls, and wet areas shall be galvanized steel pipe or cast-iron pipe. Sleeves in nonbearing walls, floors, or ceilings may be galvanized steel pipe, cast-iron pipe, or galvanized sheet metal with lock-type longitudinal seam. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve in nonfire rated walls shall be sealed as indicated and specified in Section 07 92 00 JOINT SEALANTS. Metal jackets shall be provided over insulation passing through exterior walls, firewalls, fire partitions, floors, or roofs.

a. Metal jackets shall not be thinner than 0.006 inch thick aluminum, if corrugated, and 0.016 inch thick aluminum, if smooth.

b. Metal jackets shall be secured with aluminum or stainless steel bands not less than 3/8 inch wide and not more than 8 inches apart. When penetrating roofs and before fitting the metal jacket into place, a 1/2 inch wide strip of sealant shall be run vertically along the inside of the longitudinal joint of the metal jacket from a point below the backup material to a minimum height of 36 inches above the roof. If the pipe turns from vertical to horizontal, the sealant strip shall be run to a point just beyond the first elbow. When penetrating waterproofing membrane for floors, the metal jacket shall extend from a point below the back-up material to a minimum distance of 2 inches above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 12 inches above material to a minimum distance of 2 inches above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 12 inches above the floor; when passing through walls above grade, the jacket shall extend at least 4 inches beyond each side of the wall.

3.2.12.1 Pipes Passing Through Waterproofing Membranes

In addition to the pipe sleeves referred to above, pipes passing through waterproofing membranes shall be provided with a 4 pound lead flashing or a 16 ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall set over the membrane in a troweled coating of bituminous cement. The flashing shall extend above the roof or floor a minimum of 10 inches. The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Pipes up to and including 10 inches in diameter which pass through waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

3.2.12.2 Optional Modular Mechanical Sealing Assembly

At the option of the Contractor, a modular mechanical type sealing assembly may be installed in the annular space between the sleeve and conduit or pipe in lieu of a waterproofing clamping flange and caulking and sealing specified above. The seals shall include interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion-protected carbon steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved.

3.2.12.3 Optional Counterflashing

As alternates to caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may consist of standard roof coupling for threaded pipe up to 6 inches in diameter, lead flashing sleeve for dry vents with the sleeve turned down into the pipe to form a waterproof joint, or a tack-welded or banded-metal rain shield around the pipe, sealed as indicated.

3.2.12.4 Fire Seal

Where pipes pass through firewalls, fire partitions, or floors, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.2.13 Balancing Valves

Balancing valves shall be installed as indicated.

3.2.14 Thermometer Wells

A thermometer well shall be provided in each return line for each circuit in multicircuit systems.

3.2.15 Air Vents

Air vents shall be installed where shown or directed. Air vents shall be

installed in piping at all system high points. The vent shall remain open until water rises in the tank or pipe to a predetermined level at which time it shall close tight. An overflow pipe from the vent shall be run to a point designated by the Contracting Officer's representative. The inlet to the air vent shall have a gate valve or ball valve.

3.2.16 Escutcheons

Escutcheons shall be provided at all finished surfaces where exposed piping, bare or insulated, passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be chromium-plated iron or chromium-plated brass, either one-piece or split pattern, held in place by internal spring tension or setscrews.

3.2.17 Drains

A drain connection with a 1 inch gate valve or 3/4 inch hose bib shall be installed at the lowest point in the return main near the boiler. In addition, threaded drain connections with threaded cap or plug shall be installed on the heat exchanger coil on each unit heater or unit ventilator and wherever required for thorough draining of the system.

3.2.18 Strainer Blow-Down Piping

Strainer blow-down connections shall be fitted with a black steel blow-down pipeline routed to an accessible location and provided with a blow-down valve.

3.2.19 Direct Venting for Combustion Intake Air and Exhaust Air

The intake air and exhaust vents shall be installed in accordance with NFPA 54 and boiler manufacturer's recommendations. The exhaust vent shall be sloped 1/4 inch/ft toward the boiler's flue gas condensate collection point.

3.3 GAS FUEL SYSTEM

Gas piping, fittings, valves, regulators, tests, cleaning, and adjustments shall be in accordance with the Section 23 11 25 FACILITY GAS PIPING. NFPA 54 shall be complied with unless otherwise specified. Burners, pilots, and all accessories shall be listed in UL Gas&Oil Dir. The fuel system shall be provided with a gas tight, manually operated, UL listed stop valve at the gas-supply connections, a gas strainer, a pressure regulator, pressure gauges, a burner-control valve, a safety shutoff valve suitable for size of burner and sequence of operation, and other components required for safe, efficient, and reliable operation as specified. Approved permanent and ready facilities to permit periodic valve leakage tests on the safety shutoff valve or valves shall be provided.

3.4 COLOR CODE MARKING AND FIELD PAINTING

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS. Ferrous metal not specified to be coated at the factory shall be cleaned, prepared, and painted as specified in Section 09 90 00 PAINTS AND COATINGS. Exposed pipe covering shall be painted as specified in Section 09 90 00 PAINTS AND COATINGS. Aluminum sheath over insulation shall not be painted.

3.5 TEST OF BACKFLOW PREVENTION ASSEMBLIES

Backflow prevention assemblies shall be tested in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.6 HEATING SYSTEM TESTS

The Contractor shall submit the Qualifications of the firms in charge of installation and testing as specified in the Submittals paragraph. Before any covering is installed on pipe or heating equipment, the entire heating system's piping, fittings, and terminal heating units shall be hydrostatically tested and proved tight at a pressure of 1-1/2 times the design working pressure, but not less than 100 psi. Before pressurizing system for test, items or equipment (e.g., vessels, pumps, instruments, controls, relief valves) rated for pressures below the test pressure shall be blanked off or replaced with spool pieces. Before balancing and final operating test, test blanks and spool pieces shall be removed; and protected instruments and equipment shall be reconnected. With equipment items protected, the system shall be pressurized to test pressure. Pressure shall be held for a period of time sufficient to inspect all welds, joints, and connections for leaks, but not less than 2 hours. No loss of pressure will be allowed. Leaks shall be repaired and repaired joints shall be retested. Repair joints shall not be allowed under the floor for floor radiant heating systems. If a leak occurs in tubing located under the floor in radiant heating systems, the entire zone that is leaking shall be replaced. If any repair is made above the floor for floor radiant heating systems, access shall be provided for the installed joint. Caulking of joints shall not be permitted. System shall be drained and after instruments and equipment are reconnected, the system shall be refilled with service medium and maximum operating pressure applied. The pressure shall be held while inspecting these joints and connections for leaks. The leaks shall be repaired and the repaired joints retested. Upon completion of hydrostatic tests and before acceptance of the installation, the Contractor shall balance the heating system in accordance with Section 23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS; and operating tests required to demonstrate satisfactory functional and operational efficiency shall be performed. The operating test shall cover a period of at least 24 hours for each system, and shall include, as a minimum, the following specific information in a report, together with conclusions as to the adequacy of the system:

a. Certification of balancing.

b. Time, date, and duration of test.

c. Outside and inside dry bulb temperatures.

d. Temperature of hot water supply leaving boiler.

e. Temperature of heating return water from system at boiler inlet.

f. Boiler make, type, serial number, design pressure, and rated capacity.

g. Fuel burner make, model, and rated capacity; ammeter and voltmeter readings for burner motor.

h. Circulating pump make, model, and rated capacity, and ammeter and voltmeter readings for pump motor during operation.

i. Flue-gas temperature at boiler outlet.

j. Percent carbon dioxide in flue-gas.

k. Grade or type and calorific value of fuel.

l. Draft at boiler flue-gas exit.

m. Draft or pressure in furnace.

n. Quantity of water circulated.

o. Quantity of fuel consumed.

p. Stack emission pollutants concentration.

Indicating instruments shall be read at half-hour intervals unless otherwise directed. The Contractor shall furnish all instruments, equipment, and personnel required for the tests and balancing. Obtain necessary natural gas, water and electricity as specified in the SPECIAL CONTRACT REQUIREMENTS. Operating tests shall demonstrate that fuel burners and combustion and safety controls meet the requirements of ASME CSD-1 CSA/AM Z21.13 NFPA 85.

3.6.1 Water Treatment Testing

The boiler water shall be analyzed prior to the acceptance of the facility by the water treatment company. The analysis shall include the following information recorded in accordance with ASTM D 596.

Date of Sample	_____	
Temperature	_____	degrees F
Silica (SiO2)	_____	ppm (mg/1)
Insoluble	_____	ppm (mg/1)
Iron and Aluminum Oxides	_____	ppm (mg/1)
Calcium (Ca)	_____	ppm (mg/1)
Magnesium (Mg)	_____	ppm (mg/1)
Sodium and Potassium (Na and K)	_____	ppm (mg/1)
Carbonate (HCO3)	_____	ppm (mg/1)
Sulfate (SO4)	_____	ppm (mg/1)
Chloride (C1)	_____	ppm (mg/1)
Nitrate (NO3)	_____	ppm (mg/1)
Turbidity	_____	unit
pH	_____	
Residual Chlorine	_____	ppm (mg/1)
Total Alkalinity	_____	epm (meq/1)
Noncarbonate Hardness	_____	epm (meq/1)
Total Hardness	_____	epm (meq/1)
Dissolved Solids	_____	ppm (mg/1)
Fluorine	_____	ppm (mg/1)
Conductivity	_____	micro-mho/cm

If the boiler water is not in conformance with the boiler manufacturer's recommendations, the water treatment company shall take corrective action.

3.7 CLEANING

3.7.1 Boilers and Piping

After the hydrostatic tests have been made and before the system is balanced and operating tests are performed, the boilers and feed water piping shall be thoroughly cleaned by filling the system with a solution consisting of either 1 pound of caustic soda or 1 pound of trisodium phosphate per 50 gallons of water. The proper safety precautions shall be observed in the handling and use of these chemicals. The water shall be heated to approximately 150 degrees F and the solution circulated in the system for a period of 48 hours. The system shall then be drained and thoroughly flushed out with fresh water. Strainers and valves shall be thoroughly cleaned. Prior to operating tests, air shall be removed from all water systems by operating the air vents.

3.7.2 Heating Units

Inside space heating equipment, ducts, plenums, and casing shall be thoroughly cleaned of debris and blown free of small particles of rubbish and dust and then vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for fans that are operated during construction, and new filters shall be installed after construction dirt has been removed from the building, and the ducts, plenum, casings, and other items specified have been vacuum cleaned. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.8 FUEL SYSTEM TESTS

3.8.1 Gas System Test

The gas fuel system shall be tested in accordance with the test procedures outlined in NFPA 54.

3.9 FIELD TRAINING

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The field instructions shall cover all of the items contained in the approved operation and maintenance manuals, as well as demonstrations of routine maintenance operations and boiler safety devices. The Contracting Officer shall be notified at least 14 days prior to date of proposed conduction of the training course.

-- End of Section --

SECTION 23 64 00.00 10

LIQUID CHILLERS

(AM #3)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 495	(2005) Refrigerant Liquid Receivers
ARI 550/590	(2003) Water Chilling Packages Using the Vapor Compression Cycle
ARI 700	(2004) Specifications for Fluorocarbon Refrigerants

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(1990; R 1999) Load Ratings and Fatigue Life for Roller Bearings
ABMA 9	(1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15	(2007; Errata 2007) Safety Code for Refrigeration
ASHRAE 34	(2004) Designation and Safety Classification of Refrigerants
ASHRAE 90.1 - IP	(2007; Errata 2008; Errata 2008; Errata 2008) Energy Standard for Buildings Except Low-Rise Residential Buildings, I-P Edition

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2005) Safety in Welding, Cutting and Allied Processes

ASME INTERNATIONAL (ASME)

ASME BPVC SEC IX	(2007; Addenda 2008) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2007; Addenda 2008) Boiler and Pressure

Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2007) Standard for Motors and Generators
NEMA MG 2	(2001) Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators

1.2 PROJECT REQUIREMENTS

1.2.1 Safety

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

1.2.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions. Submit detailed drawings consisting of:

a. Equipment layouts which identify assembly and installation details.

b. Plans and elevations which identify clearances required for maintenance and operation.

c. Wiring diagrams which identify each component individually and all interconnected or interlocked relationships between components.

d. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations.

e. Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings

Drawings, at least 5 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements, as specified.

SD-03 Product Data

Refrigeration System; G, DO

Manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. Data shall be adequate to demonstrate compliance with contract requirements as specified within the paragraphs:

a. Liquid Chiller

b. Chiller Components

c. Accessories

If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Posted Instructions

Posted instructions, at least 2 weeks prior to construction completion, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

Verification of Dimensions

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

Coil Corrosion Protection

Product data on the type coating selected, the coating thickness, the application process used, the estimated heat transfer loss of the coil, and verification of conformance with the salt spray test requirement.

Manufacturer's Multi-Year Compressor Warranty

(AM #3)
Chiller warranty to include 10 year parts and labor warranty on motors and compressors. (AM #3)

Manufacturer's multi-year warranty for compressor(s) in air-cooled liquid chillers as specified.

Factory Tests

Schedules, at least 2 weeks prior to the factory test, which identify the date, time, and location for each test. Schedules shall be submitted for both the Chiller Performance Test and the Chiller Sound Test. The Chiller Performance Test schedule shall also allow the witnessing of the test by a Government Representative.

System Performance Tests

A schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules shall identify the proposed date, time, and location for each test.

Demonstrations

A schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

SD-06 Test Reports

Factory Tests

Six copies of the report shall be provided in bound 8 1/2 x 11 inch booklets. Reports shall certify the compliance with performance requirements and follow the format of the required testing standard for both the Chiller Performance Tests and the Chiller Sound Tests. Test report shall include certified calibration report of all test instrumentation. Calibration report shall include certification that all test instrumentation has been calibrated within 6 months prior to the test date, identification of all instrumentation, and certification that all instrumentation complies with requirements of the test standard. Test report shall be submitted 1 week after completion of the factory test.

System Performance Tests

Six copies of the report shall be provided in bound 8 1/2 x 11 inch booklets.

SD-07 Certificates

Refrigeration System

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, 1 copy of proof of such compliance shall be provided. The label or listing of the specified agency shall be acceptable evidence. In lieu of the label or listing, a written certificate from an

approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above shall be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

Service Organization

A certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, DO

Six complete copies of an operation manual in bound 8 1/2 x 11 inch booklets. List step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. List routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

Provide spare parts data for each different item of equipment. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replace on a routine basis

A certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and

similar openings shall be capped to keep out dirt and other foreign matter.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products shall be supported by a service organization, as specified in the Submittals paragraph. System components shall be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

Major equipment including chillers, compressors, compressor drivers, condensers, liquid coolers, receivers, refrigerant leak detectors, heat exchanges, fans, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of anodized aluminum. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics shall be as shown, and unless otherwise indicated, all motors of 1 horsepower and above with open, dripproof, totally enclosed, or explosion proof fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and NEMA MG 2 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors shall be sized for the applicable loads. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

2.4 SELF-CONTAINED LIQUID CHILLER

Unless necessary for delivery purposes, units shall be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site by a factory representative. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Unit assembly shall be completed in strict accordance with manufacturer's recommendations. Chiller shall operate within capacity range and speed recommended by the manufacturer. Parts weighing 50 pounds or more which must be removed for inspection, cleaning, or repair, such as motors, gear boxes, cylinder heads, casing tops, condenser, and cooler heads, shall have lifting eyes or lugs. Chiller shall include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller shall be provided with a single point wiring connection for incoming power supply. Chiller's condenser and liquid cooler shall be provided with standard water boxes with flanged connections.

2.4.1 Centrifugal or Rotary Screw Type

Chiller shall be constructed and rated in accordance with ARI 550/590. Chiller shall have a minimum performance in accordance with ASHRAE 90.1 - IP. Chiller shall conform to ASHRAE 15 and ASHRAE 34. Chiller vibration-isolation shall be per specification 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT. As a minimum, chiller shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil

b. Structural base

c. Chiller refrigerant circuit

d. Controls package

e. Centrifugal or rotary screw compressor

f. Compressor driver, electric motor

g. Compressor driver connection

h. Liquid cooler (evaporator)

i. Water-cooled condenser coil

j. Variable flow compensation

k. Receiver

l. Purge system for chillers which operate below atmospheric pressure

m. Tools

(AM #3)
2.4.2 Chiller Efficiency

The chillers shall provide the following minimum part and full load efficiencies:

Part Load Efficiencies Chiller CH-1 and CH-2

	Minimum Efficiency		
% Load	**Chiller CH-R1-1**	**Chiller CH-R1-2**	
100	**0.500**	**0.513**	
75	**0.358**	**0.408**	
50	**0.242**	**0.327**	
25	**0.308**	**0.424**	**(AM #3)**

2.5 CHILLER COMPONENTS

2.5.1 Refrigerant and Oil

Refrigerants shall be one of the fluorocarbon gases. Refrigerants shall have number designations and safety classifications in accordance with ASHRAE 34. Refrigerants shall meet the requirements of ARI 700 as a minimum. Refrigerants shall have an Ozone Depletion Potential (ODP) of less than or equal to 0.05.

2.5.2 Structural Base

Chiller and individual chiller components shall be provided with a factory-mounted structural steel base (welded or bolted) or support legs. Chiller and individual chiller components shall be isolated from the building structure by means of vibration isolators with published load ratings. Vibration isolators shall have isolation characteristics as recommended by the manufacturer for the unit supplied and the service intended.

2.5.3 Chiller Refrigerant Circuit

Chiller refrigerant circuit shall be completely piped and factory leak tested. For multicompressor units, not less than 2 independent refrigerant circuits shall be provided. Circuit shall include as a minimum a combination filter and drier, combination sight glass and moisture indicator, liquid-line solenoid valve for reciprocating, an electronic or thermostatic expansion valve with external equalizer, charging ports, compressor service valves for field-serviceable compressors, and superheat adjustment.

2.5.4 Controls Package

Chiller shall be provided with a complete remote-mounted where indicated, prewired electric or microprocessor based control system. Controls package shall contain as a minimum a digital display or acceptable gauges, an on-auto-off switch, power wiring, and control wiring. Controls package shall provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and EMCS interfaces as defined below.

2.5.4.1 Operating Controls

Chiller shall be provided with the following adjustable operating controls as a minimum.

a. Leaving chilled water temperature control

b. Adjustable timer or automated controls to prevent a compressor from short cycling

c. Automatic lead/lag controls (adjustable) for multi-compressor units

d. Load limiting

e. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls shall automatically re-cycle the chiller on power interruption.

f. (**AM #3) Startup and head pressure controls to allow system operation at all ambient temperatures down to 55 degrees F condenser water.** ~~Startup and head pressure controls to allow system operation at all ambient temperatures down to 45 degrees F condenser water.~~ **(AM #3)**

g. Variable flow compensation

h. Water-Side Economization (free cooling) Control.

2.5.4.2 Monitoring Capabilities

During normal operations, the control system shall be capable of monitoring and displaying the following operating parameters. Access and operation of display shall not require opening or removing any panels or doors.

a. Entering and leaving chilled water temperatures

b. Self diagnostic

c. Operation status

d. Operating hours

e. Number of starts

f. Compressor status (on or off)

g. Refrigerant discharge and suction pressures

h. Oil pressure

i. Condenser water entering and leaving temperatures

j. Number of purge cycles over the last 7 days

2.5.4.3 Programmable Setpoints

The control system shall be capable of being reprogrammed directly at the unit. The programmable setpoints shall include the following as a minimum.

a. Leaving Chilled Water Temperature

b. Leaving Condenser Water Temperature

c. Time Clock/Calender Date

2.5.4.4 Safety Controls with Manual Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

a. Low chilled water temperature protection

b. High condenser refrigerant discharge pressure protection

c. Low evaporator pressure protection

d. Chilled water flow detection

e. High motor winding temperature protection

f. Low oil flow protection if applicable

g. Motor current overload and phase loss protection

2.5.4.5 Safety Controls with Automatic Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which provide automatic reset.

a. Over/under voltage protection

b. Chilled water flow interlock

2.5.4.6 Remote Alarm

During the initiation of a safety shutdown, a chiller's control system shall be capable of activating a remote alarm bell. In coordination with the chiller, the Contractor shall provide an alarm circuit (including transformer if applicable) and a minimum 4 inch diameter alarm bell. Alarm circuit shall activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell shall not sound for a chiller that uses low-pressure cutout as an operating control.

2.5.4.7 Energy Management Control System (EMCS) Interface

The control system shall be capable of communicating all data to a remote integrated DDC processor through a single shielded cable. The data shall include as a minimum all system operating conditions, capacity controls, and safety shutdown conditions. The control system shall also be capable of receiving at a minimum the following operating commands.

a. Remote Unit Start/Stop

b. Remote Chilled Water Reset

c. Remote Condenser Water Reset

(AM #3)

2.5.4.8 Chiller Plant Controller

The chiller plant controller shall provide optimized start-stop and runtime control of all chiller plant equipment. See control drawings for details. (AM #3)

2.5.5 Compressor(s)

2.5.5.1 Centrifugal Compressor(s)

Centrifugal compressors shall be single or multistage, having dynamically balanced impellers, either direct or gear driven by the compressor driver. Impellers shall be over-speed tested at 1.2 times the impeller-shaft speed. Impeller shaft shall be heat-treated alloy steel with sufficient rigidity for proper operation at any required operating speed. Centrifugal compressors shall include:

a. Shaft main bearings that are the rolling element type in accordance with ABMA 9 or ABMA 11, journal type with bronze or babbitt liners, or of the aluminum-alloy one-piece insert type. Bearings shall be rated for an L(10) life of not less than 200,000 hours.

b. Casing of cast iron, aluminum, or steel plate with split sections gasketed and bolted or clamped together.

c. Lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.

d. Provisions to ensure proper lubrication of bearings and shaft seals prior to starting and upon stopping with or without electric power supply. On units providing forced-feed lubrication prior to starting, a differential oil pressure cutout interlocked with the compressor starting equipment shall allow the compressor to operate only when the required oil pressure is provided to the bearings.

e. Oil sump heaters controlled as recommended by the manufacturer.

f. Temperature-or pressure-actuated prerotation vane or suction damper to provide automatic capacity modulation from 100 percent capacity to 10 percent capacity. If operation to 10 percent capacity cannot be achieved without providing hot-gas bypass, then the Contractor shall indicate in the equipment submittal the load percent at which hot gas bypass is required.

(AM #3)

g. Variable flow compensation

Chillers shall be capable to respond to abrupt changes in load. The chillers shall be able to vary cooling capability by 50% per minute with no significant change in chilled water supply temperature.

h. Water side economization (free cooling) control

A. A free cooling cycle shall be provided for the centrifugal chiller. The proposed chiller shall provide required material

(including controls, valves, piping, and additional storage vessels) to allow cooling of chilled water by transferring heat to cold condenser water without operating the compressor. This shall be a factory installed option on the centrifugal chiller. The following details shall apply:

1. Changeover from free cooling to mechanical cooling shall be initiated by the chiller plant controller.

2. Interlock between free cooling cycle and normal operational cycle shall be provided to prevent compressor start-up or operation during unsafe conditions.

3. Manufacturers with systems requiring spray pumps shall be responsible for any special foundations required to provide adequate pump NPSH (Net Positive Suction Head). When pump is used, provide necessary pump starter, disconnect and wiring.

4. Where spray nozzles are used, provide access provision for removal and cleaning of nozzles.

B. The contractor can, as an option, provide a plate frame heat exchanger with all the necessary piping, pumps, and controls to meet this performance. Operation must be automatic and provide for switching from chiller to heat exchanger and back.

C. Free cooling system shall provide a minimum of 10 0F delta T from entering to leaving water at 45 0F entering cooling water temperature and 2/3 evaporator flow rate; and a minimum of 8 0F delta T from entering to leaving water at 45 0F entering cooling water temperature and full evaporator flow rate. (AM #3)

2.5.6 Compressor Driver, Electric Motor

Motors, starters, variable speed drives, wiring, etc. shall be in accordance with paragraph ELECTRICAL WORK. Motor starter shall be remote mounted as indicated with starter type, wiring, and accessories coordinated with the chiller manufacturer. Starter shall be able to operate in temperatures up to 120 degrees F.

2.5.7 Compressor Driver Connections

Each machine driven through speed-increasing gears shall be so designed as to assure self-alignment, interchangeable parts, proper lubrication system, and minimum unbalanced forces. Bearings shall be of the sleeve or roller type. Gear cases shall be oil tight. Shaft extensions shall be provided with seals to retain oil and exclude all dust.

2.5.8 Liquid Cooler (Evaporator)

Cooler shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Condenser's water side shall be designed and factory pressure tested for not less than 150 psi. Cooler shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable. Tubes shall be installed into carbon mild steel tube sheets by rolling. Tube baffles

shall be properly spaced to provide adequate tube support and cross flow. Performance shall be based on a water velocity not less than 3 fps nor more than 12 fps and a fouling factor of 0.0001 h(ft2)(degrees F)/Btu.

2.5.9 Water-Cooled Condenser Coil

Condenser shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Condenser's water side shall be designed and factory pressure tested for not less than 150 psi. Condensers shall be complete with refrigerant relief valve/rupture disc assembly, water drain connections, and refrigerant charging valve. Low pressure refrigerant condenser shall be provided with a purge valve located at the highest point in the condenser to purge non-condensibles trapped in the condenser. Condenser shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable, except for the coaxial tubes. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Performance shall be based on water velocities not less than 3 fps nor more than 12 fps and a fouling factor of 0.00025 h(ft2)(degrees F)/Btu). Water-cooled condensers may be used for refrigerant storage in lieu of a separate liquid receiver, if the condenser storage capacity is 5 percent in excess of the fully charged system for single packaged systems.

2.5.10 Receivers

Liquid receivers not already specified herein as an integral factory-mounted part of a package, shall be designed, fitted, and rated in accordance with the recommendations of ARI 495, except as modified herein. Receiver shall bear a stamp certifying compliance with ASME BPVC SEC VIII D1 and shall meet the requirements of ASHRAE 15. Inner surfaces shall be thoroughly cleaned by sandblasting or other approved means. Each receiver shall have a storage capacity not less than 20 percent in excess of that required for the fully-charged system. Each receiver shall be equipped with inlet, outlet drop pipe, drain plug, purging valve, relief valves of capacity and setting required by ASHRAE 15, and two bull's eye liquid-level sight glasses. Sight glasses shall be in the same vertical plane, 90 degrees apart, perpendicular to the axis of the receiver, and not over 3 inches horizontally from the drop pipe measured along the axis of the receiver. In lieu of bull's eye sight glass, external gauge glass with metal glass guard and automatic closing stop valves may be provided.

2.5.11 Chiller Purge System

Chillers which operate at pressures below atmospheric pressure shall be provided with a purge system. Purge system shall automatically remove air, water vapor, and non-condensible gases from the chiller's refrigerant. Purge system shall condense, separate, and return all refrigerant back to the chiller. An oil separator shall be provided with the purge system if required by the manufacturer. Purge system shall not discharge to occupied areas, or create a potential hazard to personnel. Purge system shall include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system shall include lights or an alarm which indicate excessive purge or an abnormal air leakage into chiller.

2.5.12 Tools

One complete set of special tools, as recommended by the manufacturer for field maintenance of the system, shall be provided. Tools shall be mounted on a tool board in the equipment room or contained in a toolbox as directed by the Contracting Officer.

2.6 ACCESSORIES

2.6.1 Refrigerant Leak Detector

Detector shall be the continuously-operating, halogen-specific type. Detector shall be appropriate for the refrigerant in use. Detector shall be specifically designed for area monitoring and shall include 2 sampling points installed where indicated. Detector design and construction shall be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector shall have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector shall be supplied factory-calibrated for the appropriate refrigerant(s). Detector shall be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant(s) in use. The detector's relay shall be capable of initiating corresponding alarms and ventilation systems as indicated on the drawings. Detector shall be provided with a failure relay output that energizes when the monitor detects a fault in its operation. Detector shall be capable with the facility's energy management and control system (EMCS). The EMCS shall be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.

2.6.2 Refrigerant Relief Valve/Rupture Disc Assembly

The assembly shall be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly shall be in accordance with ASME BPVC SEC VIII D1 and ASHRAE 15. The assembly shall be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc shall be the non-fragmenting type.

2.6.3 Refrigerant Signs

Refrigerant signs shall be a medium-weight aluminum type with a baked enamel finish. Signs shall be suitable for indoor or outdoor service. Signs shall have a white background with red letters not less than 0.5 inches in height.

2.6.3.1 Installation Identification

Each new refrigerating system shall be provided with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name.

b. Refrigerant number and amount of refrigerant.

c. The lubricant identity and amount.

d. Field test pressure applied.

2.6.3.2 Controls and Piping Identification

Refrigerant systems containing more than 110 lb of refrigerant shall be provided with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow, the ventilation system, and the refrigerant compressor(s).

b. Pressure limiting device(s).

2.7 SUPPLEMENTAL COMPONENTS/SERVICES

2.7.1 Chilled and Condenser Water Piping and Accessories

Chilled and condenser water piping and accessories shall be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.7.2 Cooling Tower

Cooling towers shall be provided and installed in accordance with Section 23 65 00.00 10 COOLING TOWER.

2.7.3 Temperature Controls

Chiller control packages shall be fully coordinated with and integrated into the temperature control system specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM and 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform verification of dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Work shall be performed in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. Where equipment is specified to conform to the requirements of ASME BPVC SEC VIII D1and ASME BPVC SEC IX, the design, fabrication, and installation of the system shall conform to ASME BPVC SEC VIII D1 and ASME BPVC SEC IX.

3.2.1 Refrigeration System

3.2.1.1 Equipment

Refrigeration equipment and the installation thereof shall conform to ASHRAE 15. Necessary supports shall be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, liquid coolers, and similar items. Compressors shall be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations shall be provided. Each foundation shall include isolation units consisting of machine and floor or foundation fastenings, together

with intermediate isolation material. Other floor-mounted equipment shall be set on not less than a 6 inch concrete pad doweled in place. Concrete foundations for floor mounted pumps shall have a mass equivalent to three times the weight of the components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. Concrete pedestal block shall be of mass not less than three times the combined pump, motor, and base weights. Isolators shall be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Isolators shall limit vibration to 30 percent at lowest equipment rpm. Lines connected to pumps mounted on pedestal blocks shall be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE. Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.2.1.2 Field Refrigerant Charging

a. Initial Charge: Upon completion of all the refrigerant pipe tests, the vacuum on the system shall be broken by adding the required charge of dry refrigerant for which the system is designed, in accordance with the manufacturer's recommendations. Contractor shall provide the complete charge of refrigerant in accordance with manufacturer's recommendations. Upon satisfactory completion of the system performance tests, any refrigerant that has been lost from the system shall be replaced. After the system is fully operational, service valve seal caps and blanks over gauge points shall be installed and tightened.

b. Refrigerant Leakage: If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant shall be pumped into the system receiver or other suitable container. The refrigerant shall not be discharged into the atmosphere.

c. Contractor's Responsibility: The Contractor shall, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 3 ounces of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year shall be repaired in accordance with the specified requirements including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.2.1.3 Oil Charging

Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase shall be furnished. One charge shall be used during the performance testing period, and upon the satisfactory completion of the tests, the oil shall be drained and replaced with the second charge.

3.2.2 Mechanical Room Ventilation

Mechanical ventilation systems shall be in accordance with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

3.2.3 Field Applied Insulation

Field installed insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.2.4 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.3 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative shall be provided for 2 days. The representative shall advise on the following:

a. Open Machines:

(1) Erection, alignment, testing, and dehydrating.

(2) Charging the machine with refrigerant.

(3) Starting the machine.

3.4 SYSTEM PERFORMANCE TESTS

3.4.1 General Requirements

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Tests shall cover a period of not less than 48 hours for each system and shall demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened. Any refrigerant lost during the system startup shall be replaced. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and the system shall be retested. Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. Field tests shall be coordinated with Section 23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.4.2 Test Report

The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall

indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report shall also include the following information and shall be taken at least three different times at outside dry-bulb temperatures that are at least 5 degrees F apart:

a. Date and outside weather conditions.

b. The load on the system based on the following:

(1) The refrigerant used in the system.
(2) Condensing temperature and pressure.
(3) Suction temperature and pressure.
(4) For absorption units, the cooling water pressures and temperatures entering and exiting the absorber and condenser. Also the refrigerant solution pressures, concentrations, and temperatures at each measurable point within the system.
(5) Running current, voltage and proper phase sequence for each phase of all motors.
(6) The actual on-site setting of all operating and safety controls.
(7) Chilled water pressure, flow and temperature in and out of the chiller.
(8) The position of the capacity-reduction gear at machine off, one-third loaded, one-half loaded, two-thirds loaded, and fully loaded.

3.5 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions. Testing, adjusting, and balancing shall be as specified in Section 23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.6 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 16 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

-- End of Section --

SECTION 23 64 26

CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS
01/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1003	(2001; Errata, 2003) Performance Requirements for Water Pressure Reducing Valves
ASSE 1017	(2003; Errata 2004) Temperature Actuated Mixing Valves for Hot Water Distribution Systems

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2006) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2004; Errata 2004) Specification for Filler Metals for Brazing and Braze Welding
AWS BRH	(2007) Brazing Handbook
AWS D1.1/D1.1M	(2008) Structural Welding Code - Steel
AWS Z49.1	(2005) Safety in Welding, Cutting and Allied Processes

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 2006) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2005) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.11	(2005) Forged Fittings, Socket-Welding and Threaded
ASME B16.18	(2001; R 2005) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2005) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2001; R 2005) Standard for Wrought Copper

	and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2006) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(2006) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.39	(1998; R 2006) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.9	(2007) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.9	(2008) Building Services Piping
ASME B40.100	(2006) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2007; Addenda 2008) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage
CSA/ANSI Z21.22	(1999; Addenda A 2000; Addenda B 2001; R 2004) Relief Valves for Hot Water Supply Systems

ASTM INTERNATIONAL (ASTM)

ASTM A 106/A 106M	(2008) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A 183	(2003) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A 47/A 47M	(1999; R 2004) Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process
ASTM A 53/A 53M	(2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 536	(1984; R 2004) Standard Specification for Ductile Iron Castings
ASTM A 653/A 653M	(2008) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 733	(2003) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B 117	(2007a) Standing Practice for Operating

	Salt Spray (Fog) Apparatus
ASTM B 32	(2008) Standard Specification for Solder Metal
ASTM B 42	(2002e1) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B 62	(2002) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B 75	(2002) Standard Specification for Seamless Copper Tube
ASTM B 813	(2000e1) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM B 88	(2003) Standard Specification for Seamless Copper Water Tube
ASTM D 2000	(2008) Standard Classification System for Rubber Products in Automotive Applications
ASTM D 2308	(2007) Standard Specification for Thermoplastic Polyethylene Jacket for Electrical Wire and Cable
ASTM D 3308	(2006) PTFE Resin Skived Tape
ASTM D 520	(2000; R 2005) Zinc Dust Pigment
ASTM D 596	(2001; R 2006) Reporting Results of Analysis of Water
ASTM E 84	(2008a) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F 1007	(1986; R 2002) Pipeline Expansion Joints of the Packed Slip Type for Marine Application
ASTM F 1120	(1987; R 2004) Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications
ASTM F 1199	(1988; R 2004) Cast (All Temperatures and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)

CSA AMERICA, INC. (CSA/AM)

CSA/AM Z21.22	(1999; R 2004; A 2000, 2001) Relief Valves for Hot Water Supply Systems

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2003) EJMA Standards

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.5	(1994) Centrifugal Nomenclature

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE Std 515	(2004) Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-110	(1996) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
MSS SP-25	(1998) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2002) Standard for Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-67	(2002a; R 2004) Standard for Butterfly Valves
MSS SP-69	(2003; R 2004) Standard for Pipe Hangers and Supports - Selection and Application
MSS SP-70	(2006) Standard for Cast Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2005) Standard for Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(1999) Standard for Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-78	(2005a) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(2008) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2002) Standard for Cast Iron Globe & Angle Valves, Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2003) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2007) Standard for Motors and Generators
NEMA MG 11	(1977; R 2007) Energy Management Guide for

Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A (2008) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-50541 (Basic; Notice 1) Valves, Tank Float, Angle and Globe Pattern (Inch-Pound

1.2 SYSTEM DESCRIPTION

Provide the water systems having the minimum service (design) temperature-pressure rating indicated. Provision of the piping systems, including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with the required and advisory provisions of ASME B31.9 except as modified or supplemented by this specification section or design drawings. This specification section covers the water systems piping which is located within, on, and adjacent to building(s) within the building(s) 5 foot line.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Calibrated Balancing Valves; G, DO

Automatic Flow Control Valves; G, DO

Pump Discharge Valve

Water Temperature Mixing Valve; G, DO

Water Temperature Regulating Valves; G, DO

Water Pressure Reducing Valve

Pressure Relief Valve

Combination Pressure and Temperature Relief Valves

Expansion Joints; G, DO

Pumps; G, DO

Combination Strainer and Pump Suction Diffuser

Expansion Tanks

Air Separator Tanks

Water Treatment Systems; G, DO

Electrical Heat Tracing; G, DO

Proposed water treatment plan including a layout, control scheme, a list of existing make-up water conditions including the items listed in paragraph "Water Analysis", a list of chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals.

SD-06 Test Reports

Piping welds NDE report

Pressure tests reports; G, DO

Report shall be provided in bound 8 1/2 by 11 inch booklets. In the reports, document all phases of the tests performed. Include initial test summaries, all repairs/adjustments made, and the final test results.

Condenser Water Quality Test Reports; G, DO

Test reports, each month for a period of one year after project completion, in bound 8-1/2 by 11 inch booklets. In the reports, identify the chemical composition of the condenser water. Also include the comparison of the manufacturer's recommended operating conditions for the cooling tower and condenser in relation to the condition of the condenser water. Document in the report any required corrective action taken.

One-Year Inspection Report For Cooling Water; G, DO

At the completion of one year of service, in bound 8-1/2 by 11 inch booklets. In the report, identify the condition of each cooling tower and condenser. Include a comparison of the condition of the cooling tower and condenser with the manufacturer's recommended operating conditions. Identify all actions taken by the Contractor and manufacturer to correct deficiencies during the first year of service.

SD-08 Manufacturer's Instructions

Lesson plan for the Instruction Course; G, DO

SD-10 Operation and Maintenance Data

Requirements for data packages are specified Section 01 78 23 OPERATION AND MAINTENANCE DATA,except as supplemented and modified by this specification section.

Submit spare parts data for each different item of equipment specified, with operation and maintenance data packages. Include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

Water Treatment Systems; G, DO

An operation manual in bound 8 1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown. Include testing procedures used in determining water quality.

A maintenance manual in bound 8 1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide.

Calibrated Balancing Valves, Data Package 3

Automatic Flow Control Valves, Data Package 3

Pump Discharge Valve, Data Package 2

Water Temperature Mixing Valve, Data Package 3

Water Temperature Regulating Valves, Data Package 3

Water Pressure Reducing Valve, Data Package 3

Pressure Relief Valve, Data Package 2

Combination Pressure and Temperature Relief Valves, Data Package 2

Expansion Joints, Data Package 2

Pumps, Data Package 3

Combination Strainer and Pump Suction Diffuser, Data Package 2

Expansion Tanks, Data Package 2

Air Separator Tanks, Data Package 2

Compression Tanks, Data Package 2; G, DO

1.4 MODIFICATIONS TO REFERENCES

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.4.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.4.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.5 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired.

1.6 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, cap piping and similar openings to keep out dirt and other foreign matter. Any porous materials found to be contaminated with mold or mildew will be replaced at the Contractor's expense. Non-porous materials found to be contaminated with mold or mildew will be disinfected and cleaned prior to installation.

1.7 PROJECT/SITE CONDITIONS

1.7.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.7.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.7.3 Accessibility

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening.

The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures.

Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. System components shall be environmentally suitable for the indicated locations.

The equipment items shall be supported by service organizations. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

2.2 ELECTRICAL HEAT TRACING

Heat trace systems for pipes, valves, and fittings shall be in accordance with IEEE Std 515 and be UL listed. System shall include all necessary components, including heaters and controls to prevent freezing.

Provide self-regulating heaters consisting of two 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature along its length. Heater shall be able to be crossed over itself without overheating and be approved before used directly on plastic pipe. Heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket in accordance with ASTM D 2308.

For installation on plastic piping, apply the heater using aluminum tape. Heater shall have an outer braid of tinned-copper and an outer jacket of modified polyolefin in accordance with ASTM D 2308, to provide a good ground path and to enhance the heater's ruggedness.

Provide heater with self-regulating factor of at least 90 percent, in order to provide energy conservation and to prevent overheating.

Heater shall operate on line voltages of 120, 208, 220, 240, 277, volts without the use of transformers.

Size Heater according to the following table:

Pipe Size (Inch, Diameter)	Minus 10 degrees F	Minus 20 degrees F
3 inches or less	5 watts per foot (wpf)	5 wpf
4 inch	5 wpf	8 wpf

Pipe Size (Inch, Diameter)	Minus 10 degrees F	Minus 20 degrees F
6 inch	8 wpf	8 wpf
8 inch	2 strips/5 wpf	2 strips/8 wpf
12 inch to 14 inch	2 strips/8 wpf	2 strips/8 wpf

System shall be controlled by an ambient sensing thermostat set at 40 degrees F either directly or through an appropriate contactor.

2.3 STEEL PIPING

Water piping shall be steel pipe or copper tubing. Provide steel piping with a ANSI/ASME Class 125 service rating, which for 150 degrees F, the pressure rating is 175 psig.

2.3.1 Pipe

Steel pipe, conform to ASTM A 53/A 53M, Schedule 40, Type E or S, Grades A or B. Do not use Type F pipe.

2.3.2 Fittings and End Connections (Joints)

Piping and fittings 1 inch and smaller shall have threaded connections. Piping and fittings larger than 1 inch and smaller than 3 inches shall have either threaded, grooved, or welded connections. Piping and fittings 3 inches and larger shall have grooved, welded, or flanged connections. The manufacturer of each fitting shall be permanently identified on the body of the fitting in accordance with MSS SP-25.

2.3.2.1 Threaded Connections

Use threaded valves and pipe connections conforming to ASME B1.20.1. Used threaded fitting conforming to ASME B16.3. Use threaded unions conforming to ASME B16.39. Use threaded pipe nipples conforming to ASTM A 733.

2.3.2.2 Flanged Connections

Flanges shall conform to ASME B16.1, Class 150. Gaskets shall be nonasbestos compressed material in accordance with ASME B16.21, 1/16 inch thickness, full face or self-centering flat ring type. These gaskets shall contain aramid fibers bonded with styrene butadeine rubber (SBR) or nitrile butadeine rubber (NBR). Bolts, nuts, and bolt patterns shall conform to ASME B16.1.

2.3.2.3 Welded Connections

Welded valves and pipe connections (both butt-welds and socket-welds types) shall conform to ASME B31.9. Butt-welded fittings shall conform to ASME B16.9. Socket-welded fittings shall conform to ASME B16.11. Welded fittings shall be identified with the appropriate grade and marking symbol.

2.3.2.4 Grooved Mechanical Connections For Steel

Rigid grooved mechanical connections may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 230 degrees F. Flexible grooved connections shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria

specified for the similar welded, flanged, or threaded component specified herein.

Each grooved mechanical joint shall be a system, including coupling housing, gasket, fasteners, all furnished by the same manufacturer. Joint installation shall be in compliance with joint manufacturer's written instructions.

Use fitting and coupling houses of malleable iron conforming to ASTM A 47/A 47M, Grade 32510; ductile iron conforming to ASTM A 536, Grade 65-45-12; or steel conforming ASTM A 106/A 106M, Grade B or ASTM A 53/A 53M. Use gaskets of molded synthetic rubber with central cavity, pressure responsive configuration and conforming to ASTM D 2000 Grade No. 2CA615A15B44F17Z for circulating medium up to 230 degrees F or Grade No. M3BA610A15B44Z for circulating medium up to 200 degrees F. Grooved mechanical connections shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A 183. Pipe connections and fittings shall be the product of the same manufacturer. Provide joint installation be in compliance with joint manufacturer's written instructions.

2.3.2.5 Dielectric Waterways and Flanges

Provide dielectric waterways with a water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint. When dry, insulation barrier shall be able to withstand a 600-volt breakdown test. Provide dielectric waterways constructed of galvanized steel and have threaded end connections to match connecting piping. Dielectric waterways shall be suitable for the required operating pressures and temperatures. Provide dielectric flanges with the same pressure ratings as standard flanges and provide complete electrical isolation between connecting pipe and/or equipment as described herein for dielectric waterways.

2.4 COPPER TUBING

Provide copper tubing and fittings with a ANSI/ASME Class 125 service rating, which for 150 degrees F., the pressure rating is 175 psig.

2.4.1 Tube

Use copper tube conforming to ASTM B 88, Type L or M for aboveground tubing, and Type K for buried tubing.

2.4.2 Fittings and End Connections (Solder and Flared Joints)

Wrought copper and bronze solder joint pressure fittings, including unions and flanges, shall conform to ASME B16.22 and ASTM B 75. Provide adapters as required. Cast copper alloy solder-joint pressure fittings , including unions and flanges, shall conform to ASME B16.18. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B 62. ASTM B 42 copper pipe nipples with threaded end connections shall conform to ASTM B 42.

Copper tubing of sizes larger than 4 inches shall have brazed joints.Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

Extracted brazed tee joints may be used if produced with an acceptable tool

and installed in accordance with tool manufacturer's written procedures.

2.4.3 Grooved Mechanical Connections For Copper

Rigid grooved mechanical connections may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 230 degrees F. Flexible grooved connections shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein.

Each grooved mechanical joint shall be a system, including coupling housing, gasket, fasteners, all furnished by the same manufacturer. Joint installation shall be in compliance with joint manufacturer's written instructions.

Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A 536. Provide gaskets for use in grooved joints shall constructed of molded synthetic polymer of pressure responsive design and shall conform to ASTM D 2000 for circulating medium up to 230 degrees F. Provide grooved joints in conformance with AWWA C606.

2.4.4 Solder

Provide solder in conformance with ASTM B 32, grade Sb5, tin-antimony alloy. Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B 813.

2.4.5 Brazing Filler Metal

Filler metal shall conform to AWS A5.8/A5.8M, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.5 VALVES

Provide valves with a ANSI/ASME Class 125 service rating, which for 150 degrees F, the pressure rating is 175 psig.

Valves in sizes larger than 1 inch and used on steel pipe systems, may be provided with rigid grooved mechanical joint ends. Such grooved end valves shall be subject to the same requirements as rigid grooved mechanical joints and fittings and, shall be furnished by the same manufacturer as the grooved pipe joint and fitting system.

2.5.1 Gate Valve

Gate valves 2-1/2 inches and smaller shall conform to MSS SP-80 Class 125 and shall be bronze with wedge disc, rising stem and threaded, soldered, or flanged ends. Gate valves 3 inches and larger shall conform to MSS SP-70, Class 125, cast iron with bronze trim, outside screw and yoke, and flanged or threaded ends.

2.5.2 Globe and Angle Valve

Globe and angle valves 2-1/2 inches and smaller shall conform to MSS SP-80, Class 125. Globe and angle valves 3 inches and larger shall conform to MSS SP-85, Class 125.

2.5.3 Check Valve

Check valves 2-1/2 inches and smaller shall conform to MSS SP-80. Check valves 3 inches and larger shall conform to MSS SP-71, Class 125.

2.5.4 Butterfly Valve

Butterfly valves shall conform to MSS SP-67, Type 1 and shall be either the wafer or lug type. Valves smaller than 8 inches shall have throttling handles with a minimum of seven locking positions. Valves 8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators.

2.5.5 Plug Valve

Plug valves 2 inches and larger shall conform to MSS SP-78, have flanged or threaded ends, and have cast iron bodies with bronze trim. Valves 2 inches and smaller shall be bronze with NPT connections for black steel pipe and brazed connections for copper tubing. Valve shall be lubricated, non-lubricated, or tetrafluoroethylene resin-coated type. Valve shall be resilient, double seated, trunnion mounted with tapered lift plug capable of 2-way shutoff. Valve shall operate from fully open to fully closed by rotation of the handwheel to lift and turn the plug. Valve shall a weatherproof operators with mechanical position indicators. Valves 8 inches or larger shall be provided with manual gear operators with position indicators.

2.5.6 Ball Valve

Full port design. Ball valves 1/2 inch and larger shall conform to MSS SP-72 or MSS SP-110 and shall be cast iron or bronze with threaded, soldered, or flanged ends. Valves 8 inches or larger shall be provided with manual gear operators with position indicators. Ball valves may be provided in lieu of gate valves.

2.5.7 Square Head Cocks

Provide copper alloy or cast-iron body with copper alloy plugs, suitable for 125 psig water working pressure.

2.5.8 Calibrated Balancing Valves

Copper alloy or cast iron body, copper alloy or stainless internal working parts. Provide valve calibrated so that flow can be determined when the temperature and pressure differential across valve is known. Valve shall have an integral pointer which registers the degree of valve opening. Valve shall function as a service valve when in fully closed position. Valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation.

Provide valve bodies with tapped openings and pipe extensions with positive shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable differential pressure meter connections to verify the pressure differential. Provide metal tag on each valve showing the gallons per minute flow for each differential pressure reading.

2.5.9 Automatic Flow Control Valves

Valve shall automatically maintain the constant flow indicated on the design drawings. Valve shall modulate by sensing the pressure differential across the valve body. Valve shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Provide valve that controls the flow within 5 percent of the tag rating. Valve materials shall be the same as specified for the ball or plug valves.

Provide valve that are electric type as indicated. Valve shall be capable of positive shutoff against the system pump head, valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings and differential meter, suitable for the operating pressure specified. Provide the meter complete with hoses, vent, integral metering connections, and carrying case as recommended by the valve manufacturer.

2.5.10 Pump Discharge Valve

Valve shall shall perform the functions of a nonslam check valve, a manual balancing valve, and a shutoff. Valve shall be of cast iron or ductile iron construction with bronze and/or stainless steel accessories. Provide an integral pointer on the valve which registers the degree of valve opening. Flow through the valve shall be manually adjustable from bubble tight shutoff to full flow. Valves smaller than 2 inches shall have NPT connections. Valves 2 inches and larger shall have flanged or grooved end connections. Valve design shall allow the back seat for the stem to be replaced in the field under full line pressure.

2.5.11 Water Temperature Mixing Valve

Valve, ASSE 1017 for water service.

2.5.12 Water Temperature Regulating Valves

Provide copper alloy body, direct acting, pilot operated, for the intended service.

2.5.13 Water Pressure Reducing Valve

Valve, ASSE 1003 for water service, copper alloy body, automatic re-seating, with test lever.

2.5.14 Pressure Relief Valve

Valve shall prevent excessive pressure in the piping system when the piping system reaches its maximum heat buildup. Valve, CSA/AM Z21.22 and shall have cast iron bodies with corrosion resistant internal working parts. The discharge pipe from the relief valve shall be the size of the valve outlet unless otherwise indicated.

2.5.15 Combination Pressure and Temperature Relief Valves

CSA/AM Z21.22, copper alloy body, automatic re-seating, test lever, and discharge capacity based on AGA temperature steam rating.

2.5.16 Float Valve

Valve, CID A-A-50541, Style A (angle pattern) or Style B (globe pattern). Where float rods are extended for tank applications, extension shall be properly supported and guided to avoid bending of float rod or stressing of valve pilot linkage.

2.5.17 Drain Valves

Valves, MSS SP-80 gate valves. Valve shall be manually-operated, 3/4 inch pipe size and above with a threaded end connection. Provide valve with a water hose nipple adapter. Freeze-proof type valves shall be provided in installations exposed to freezing temperatures.

2.5.18 Air Venting Valves

Manually-operated general service type air venting valves, brass or bronze valves that are furnished with threaded plugs or caps. Automatic type air venting shall be the ball-float type with brass/bronze or brass bodies, 300 series corrosion-resistant steel float, linkage and removable seat. Air venting valves on water coils shall have not less than 1/8 inch threaded end connections. Air venting valves on water mains shall have not less than 3/4 inch threaded end connections. Air venting valves on all other applications shall have not less than 1/2 inch threaded end connections.

2.5.19 Vacuum Relief Valves

CSA/ANSI Z21.22

2.6 PIPING ACCESSORIES

2.6.1 Strainer

Strainer, ASTM F 1199, except as modified and supplemented in this specification. Strainer shall be the cleanable, basket or "Y" type, the same size as the pipeline. Strainer bodies shall be fabricated of cast iron with bottoms drilled, and tapped. Provide blowoff outlet with pipe nipple, gate valve, and discharge pipe nipple. The bodies shall have arrows clearly cast on the sides indicating the direction of flow.

Provide strainer with removable cover and sediment screen. The screen shall be made of minimum 22 gauge brass sheet, monel, corrosion-resistant steel, with small perforations numbering not less than 400 per square inch to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

2.6.2 Cyclonic Separator

Metal- bodied, with removal capability of removing solids 45 microns/325 mesh in size and heavier than 1.20 specific gravity, maximum pressure drop of 5 psid, with cleanout connection.

2.6.3 Combination Strainer and Pump Suction Diffuser

Angle type body with removable strainer basket and internal straightening vanes, a suction pipe support, and a blowdown outlet and plug. Strainer shall be in accordance with ASTM F 1199, except as modified and

supplemented by this specification. Unit body shall have arrows clearly cast on the sides indicating the direction of flow.

Strainer screen shall be made of minimum 22 gauge brass sheet, monel, corrosion-resistant steel, with small perforations numbering not less than 400 per square inchto provide a net free area through the basket of at least 3.30 times that of the entering pipe. Flow shall be into the screen and out through the perforations. Provide an auxiliary disposable fine mesh strainer which shall be removed 30 days after start-up. Provide warning tag for operator indicating scheduled date for removal.

Casing shall have connection sizes to match pump suction and pipe sizes, and be provided with adjustable support foot or support foot boss to relieve piping strains at pump suction. Provide unit casing with blowdown port and plug. Provide a magnetic insert to remove debris from system.

2.6.4 Flexible Pipe Connectors

Provide flexible bronze or stainless steel piping connectors with single braid. Equip flanged assemblies with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Provide covers to protect the bellows where indicated.

2.6.5 Pressure and Vacuum Gauges

Gauges, ASME B40.100 with throttling type needle valve or a pulsation dampener and shut-off valve. Provide gauges with 4.5 inch dial, brass or aluminum case, bronze tube, and siphon. Gauge shall have a minimum of with a range from 0 psig to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.

2.6.6 Temperature Gauges

Temperature gauges, shall be the industrial duty type and be provided for the required temperature range. Provide gauges with fixed thread connection, dial face gasketed within the case; and an accuracy within 2 percent of scale range. Gauges shall have Fahrenheit scale in 2 degree graduations scale (black numbers) on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 5 feet of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 5 to 7 feet above the finished floor or in locations indicated. Remote element type temperature gauges shall be provided in thermal wells located 7 feet above the finished floor or in locations indicated.

2.6.6.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, 9 inches long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

2.6.6.2 Bimetallic Dial

Bimetallic dial type case shall be not less than 3-1/2 inches, stainless

steel, and shall be hermetically sealed with clear acrylic lens. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment.

2.6.6.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than 3-1/2 inches, stainless steel or cast aluminum with clear acrylic lens. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

2.6.6.4 Thermal Well

Thermal well shall be identical size, 1/2 or 3/4 inch NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 1/2 inch NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Mercury shall not be used in thermometers. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 1 inch.

2.6.7 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, guides, and supports: to MSS SP-58 and MSS SP-69.

2.6.8 Escutcheons

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Secure plates in place by internal spring tension or set screws. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.6.9 Expansion Joints

2.6.9.1 Slip-Tube Type

Slip-tube expansion joints, ASTM F 1007, Class I or II. Joints shall be provided with internally-externally alignment guides, injected semi-plastic packing, and service outlets. End connections shall be flanged or beveled for welding as indicated. Initial settings shall be made in accordance with the manufacturer's recommendations to compensate for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer.

2.6.9.2 Flexible Ball Type

Flexible ball expansion joints shall be capable of 360 degrees rotation plus 15 degrees angular flex movement. Joints shall be constructed of carbon steel with the exterior spherical surface of carbon steel balls plated with a minimum 5 mils of hard chrome in accordance with EJMA Stds. Joint end connections shall be threaded for piping 2 inches or smaller. Joint end connections larger than 2 inches shall be grooved, flanged, or beveled for welding. Provide joint with pressure-molded composition gaskets suitable for continuous operation at twice design temperature.

2.6.9.3 Bellows Type

Bellows expansion type joints, ASTM F 1120 with Type 304 stainless steel corrugated bellows, reinforced with equalizing rings, internal sleeves, and

external protective covers. Joint end connections shall be grooved, flanged, or beveled for welding. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint.

2.7 PUMPS

Pumps shall be the electrically driven, non-overloading, centrifugal type which conform to HI 1.1-1.5. Pumps shall be selected at or within 5 percent of peak efficiency. Pump curve shall rise continuously from maximum capacity to shutoff. Pump motor shall conform to NEMA MG 1, be totally enclosed, and have sufficient horsepower for the service required. Pump motor shall have the required capacity to prevent overloading with pump operating at any point on its characteristic curve. Pump speed shall not exceed 3,600 rpm, except where the pump head is less than 60 feet of water, the pump speed shall not exceed 1,750 rpm. Pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in the cover.

2.7.1 Construction

Each pump casing shall be designed to withstand the discharge head specified plus the static head on system plus 50 percent of the total, but not less than 125 psig. Pump casing and bearing housing shall be close grained cast iron. High points in the casing shall be provided with manual air vents; low points shall be provided with drain plugs. Provide threaded suction and discharge pressure gage tapping with square-head plugs.

Impeller shall be statically and dynamically balanced. Impeller, impeller wearing rings, glands, casing wear rings, and shaft sleeve shall be bronze. Shaft shall be carbon or alloy steel, turned and ground. Bearings shall be ball-bearings, roller-bearings, or oil-lubricated bronze-sleeve type bearings, and be efficiently sealed or isolated to prevent loss of oil or entrance of dirt or water.

Pump and motor shall be mounted on a common cast iron base having lipped edges and tapped drainage openings or structural steel base with lipped edges or drain pan and tapped drainage openings.Pump shall be provided with steel shaft coupling guard. Base-mounted pump, coupling guard, and motor shall each be bolted to a fabricated steel base which shall have bolt holes for securing base to supporting surface. Close-coupled pump shall be provided with integrally cast or fabricated steel feet with bolt holes for securing feet to supporting surface. Close- coupled pumps shall be provided with drip pockets and tapped openings. Pump shall be accessible for servicing without disturbing piping connections. Shaft seals shall be mechanical-seals or stuffing-box type.

2.7.2 Mechanical Shaft Seals

Seals shall be single, inside mounted, end-face-elastomer bellows type with stainless steel spring, brass or stainless steel seal head, carbon rotating face, and tungsten carbide or ceramic sealing face. Glands shall be bronze and of the water-flush design to provide lubrication flush across the face of the seal. Bypass line from pump discharge to flush connection in gland shall be provided, with filter or cyclone particle separator in line.

2.8 EXPANSION TANKS

Tank shall be welded steel, constructed for, and tested to

pressure-temperature rating of 125 psi at 150 degrees F. Provide tanks precharged to the minimum operating pressure. Tank shall have a replaceable polypropylene or butyl lined diaphragm which keeps the air charge separated from the water; shall be the captive air type.

Tanks shall accommodate expanded water of the system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. Each tank air chamber shall be fitted with a drain, fill, an air charging valve, and system connections. Tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The only air in the system shall be the permanent sealed-in air cushion contained within the expansion tank.

2.9 AIR SEPARATOR TANKS

External air separation tank shall have an internal design constructed of stainless steel and suitable for creating the required vortex and subsequent air separation. Tank shall be steel, constructed for, and tested to pressure-temperature rating of 125 psi at 150 degrees F.. Tank shall have tangential inlets and outlets connections, threaded for 2 inches and smaller and flanged for sizes 2 1/2 inches and larger. Air released from a tank shall be vented as indicated. Tank shall be provided with a blow-down connection.

Design to separate air from water and to direct released air to automatic air vent. Unit shall be of one piece cast-iron construction with internal baffles and two air chambers at top of unit; one air chamber shall have outlet to expansion tank and other air chamber shall be provided with automatic air release device. Tank shall be steel, constructed for, and tested to a ANSI Class 125 pressure-temperature rating.

2.10 Compression Tanks

Provide compression tank designed, fabricated, tested, and stamped for a working pressure of not less than 125 psi in accordance with ASME BPVC SEC VIII D1. Tank shall be hot-dip galvanized after fabrication to produce not less than 1.5 ounces of zinc coating per square foot of single-side surface.

2.11 WATER TREATMENT SYSTEMS

When water treatment is specified, the use of chemical-treatment products containing equivalent chromium (CPR) is prohibited.

2.11.1 Chilled and Condenser Water

Water to be used in the chilled and condenser water systems shall be treated to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Chemicals shall meet all required federal, state, and local environmental regulations for the treatment of evaporator coils and direct discharge to the sanitary sewer.

2.11.2 Water Treatment Services

The services of a company regularly engaged in the treatment of condenser, and chilled water systems shall be used to determine the correct chemicals required, the concentrations required, and the water treatment equipment

sizes and flow rates required. The company shall maintain the chemical treatment and provide all chemicals required for the condenser, and chilled and heating water systems for a period of 1 year from the date of occupancy. The chemical treatment and services provided over the 1 year period shall meet the requirements of this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Acid treatment and proprietary chemicals shall not be used.

2.11.3 Chilled and Closed Condenser Water System

A shot feeder shall be provided on the chilled water piping as indicated. Size and capacity of feeder shall be based on local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.11.4 Condenser Water

The water treatment system shall be capable of automatically feeding chemicals and bleeding the system to prevent corrosion, scale, and biological formations. Automatic chemical feed systems shall automatically feed chemicals into the condenser water based on varying system conditions.

2.11.4.1 Chemical Feed Pump

One pump shall be provided for each chemical feed tank. The chemical feed pumps shall be positive displacement diaphragm type. The flow rate of the pumps shall be adjustable from 0 to 100 percent while in operation. The discharge pressure of pumps shall not be less than 1.5 times the line pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge.

2.11.4.2 Tanks

Two chemical tanks shall be provided. The tanks shall be constructed of high density polyethylene with a hinged cover. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation. A level indicating device shall be included with each tank. An electric agitator shall be provided for each tank.

2.11.4.3 Injection Assembly

An injection assembly shall be provided at each chemical injection point along the condenser water piping as indicated. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the condenser water piping. Each assembly shall include a shutoff valve and check valve at the point of entrance into the condenser water line.

2.11.4.4 Water Meter

Water meters shall be provided with an electric contacting register and remote accumulative counter. The meter shall be installed within the make-up water line, as indicated.

2.11.4.5 Timers

Timers shall be of the automatic reset, adjustable type, and electrically operated. The timers shall be suitable for a 120 volt current. The timers shall be located within the water treatment control panel.

2.11.4.6 Water Treatment Control Panel

The control panel shall be a NEMA 12 enclosure suitable for surface mounting. The panel shall be constructed of stainless steel with a hinged door and lock. The panel shall contain a laminated plastic nameplate identifying each of the following functions:

(1) Main power switch and indicating light
(2) MAN-OFF-AUTO selector switch
(3) Indicating lamp for bleed-off valve
(4) Indicating lamp for each chemical feed pump
(5) Set point reading for each timer

2.11.4.7 Chemical Piping

The piping and fittings shall be constructed suitable for the water treatment chemicals.

2.11.4.8 Sequence of Operation

The chemicals shall be added based upon sensing the make-up water flow rate and activating appropriate timers. A separate timer shall be provided for each chemical. The blow down shall be controlled based upon the make-up water flow rate and a separate timer. The injection of the chemical required for biological control shall be controlled by a timer which can be manually set for proper chemical feed. Timer set points, blow down rates, and chemical pump flow rates shall be determined and set by the water treatment company.

2.11.4.9 Test Kits

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided.

2.12 ELECTRICAL WORK

Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers including the required monitors and timed restart.

Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

Provide polyphase, squirrel-cage medium induction motors, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor.

Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop

operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use solid-state variable-speed controllers for motors rated 7.45 kW (10 hp) or less and adjustable frequency drives for larger motors.

2.13 PAINTING OF NEW EQUIPMENT

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

2.13.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided. The factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test.

Salt-spray fog test shall be in accordance with ASTM B 117, and for that test, the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shall show no signs of rust creepage beyond 0.125 inch on either side of the scratch mark. The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen.

If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system shall be designed for the temperature service.

2.13.2 Shop Painting Systems for Metal Surfaces

Clean, retreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F shall be cleaned to bare metal.

Where hot-dip galvanized steel has been cut, resulting surfaces with no galvanizing shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F shall receive one coat of pretreatment primer applied to a minimum

dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat.

b. Temperatures Between 120 and 400 degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F shall receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.

c. Temperatures Greater Than 400 degrees F: Metal surfaces subject to temperatures greater than 400 degrees F shall receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

2.14 FACTORY APPLIED INSULATION

Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E 84.

Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E 84.

2.15 NAMEPLATES

Major equipment including pumps, pump motors, expansion tanks, and air separator tanks shall have the manufacturer's name, type or style, model or serial number on a plate secured to the item of equipment. The nameplate of the distributing agent will not be acceptable. Plates shall be durable and legible throughout equipment life. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.16 RELATED COMPONENTS/SERVICES

2.16.1 Drain and Make-Up Water Piping

Requirements for drain and make-up water piping and backflow preventer's is specified in Section 22 00 00 PLUMBING SYSTEMS.

2.16.2 Field Applied Insulation

Requirements for field applied insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.16.3 Field Applied Insulation

Requirements for field installed insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as supplemented and modified by this specification section.

2.16.4 Field Painting

Requirements for painting of surfaces not otherwise specified, and finish painting of items only primed at the factory, are specified in Section 09 90 00PAINTING, GENERAL.

2.16.4.1 Color Coding

Requirements for color coding for piping identification are specified in Section 09 90 00 PAINTING AND COATINGS.

2.16.4.2 Color Coding For Hidden Piping

A color coding scheme for locating hidden piping shall be in accordance with Section 22 00 00 PLUMBING SYSTEMS.

PART 3 EXECUTION

3.1 INSTALLATION

Cut pipe accurately to measurements established at the jobsite, and work into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation is not permitted without written approval. Cut pipe or tubing square, remove burrs by reaming, and fashion to permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.1 Welding

Provide welding work specified this section for piping systems in conformance with ASME B31.9, as modified and supplemented by this specification section and the accompanying drawings. The welding work includes: qualification of welding procedures, welders, welding operators, brazers, brazing operators, and nondestructive examination personnel; maintenance of welding records, and examination methods for welds.

3.1.1.1 Employer's Record Documents (For Welding)

Submit for review and approval the following documentation. This documentation and the subject qualifications shall be in compliance with ASME B31.9.

a. List of qualified welding procedures that is proposed to be used to provide the work specified in this specification section.

b. List of qualified welders, brazers, welding operators, and brazing operators that are proposed to be used to provide the work specified in this specification section.

c. List of qualified weld examination personnel that are proposed to be used to provide the work specified in this specification

section.

3.1.1.2 Welding Procedures and Qualifications

a. Specifications and Test Results: Submit copies of the welding procedures specifications and procedure qualification test results for each type of welding required. Approval of any procedure does not relieve the Contractor of the responsibility for producing acceptable welds. Submit this information on the forms printed in ASME BPVC SEC IX or their equivalent.

b. Certification: Before assigning welders or welding operators to the work, submit a list of qualified welders, together with data and certification that each individual is performance qualified as specified. Do not start welding work prior to submitting welder, and welding operator qualifications. The certification shall state the type of welding and positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

3.1.1.3 Examination of Piping Welds

Conduct non-destructive examinations (NDE) on piping welds and brazing and verify the work meets the acceptance criteria specified in ASME B31.9. NDE on piping welds covered by ASME B31.9 is visual inspection only. Submit a piping welds NDE report meeting the requirements specified in ASME B31.9.

3.1.1.4 Welding Safety

Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

3.1.2 Directional Changes

Make changes in direction with fittings, except that bending of pipe 4 inches and smaller is permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees is not permitted. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations is not acceptable.

3.1.3 Functional Requirements

Pitch horizontal supply mains down in the direction of flow as indicated. The grade shall not be less than 1 inch in 40 feet. Reducing fittings shall be used for changes in pipe sizes. Cap or plug open ends of pipelines and equipment during installation to keep dirt or other foreign materials out of the system.

Pipe not otherwise specified shall be uncoated. Connections to appliances shall be made with malleable iron unions for steel pipe 2-1/2 inches or less in diameter, and with flanges for pipe 3 inches and above in diameter. Connections between ferrous and copper piping shall be electrically isolated from each other with dielectric waterways or flanges.

Piping located in air plenums shall conform to NFPA 90A requirements. Pipe

and fittings installed in inaccessible conduits or trenches under concrete floor slabs shall be welded. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance. Electric isolation fittings shall be provided between dissimilar metals.

3.1.4 Fittings and End Connections

3.1.4.1 Threaded Connections

Threaded connections shall be made with tapered threads and made tight with PTFE tape complying with ASTM D 3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.1.4.2 Brazed Connections

Brazing, AWS BRH, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Do not use brazing flux. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Piping shall be supported prior to brazing and not be sprung or forced.

3.1.4.3 Welded Connections

Branch connections shall be made with welding tees or forged welding branch outlets. Pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding, the pipe and fittings shall be filled with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.9. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with AWS D1.1/D1.1M or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.4.4 Grooved Mechanical Connections

Prepare grooves in accordance with the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, or narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

3.1.4.5 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.1.4.6 Flanges and Unions

Except where copper tubing is used, union or flanged joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Flanged joints shall be assembled square end tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for the intended application.

3.1.5 Valves

Isolation gate or ball valves shall be installed on each side of each piece of equipment, at the midpoint of all looped mains, and at any other points indicated or required for draining, isolating, or sectionalizing purpose. Isolation valves may be omitted where balancing cocks are installed to provide both balancing and isolation functions. Each valve except check valves shall be identified. Valves in horizontal lines shall be installed with stems horizontal or above.

3.1.6 Air Vents

Air vents shall be provided at all high points, on all water coils, and where indicated to ensure adequate venting of the piping system.

3.1.7 Drains

Drains shall be provided at all low points and where indicated to ensure complete drainage of the piping. Drains shall be accessible, and shall consist of nipples and caps or plugged tees unless otherwise indicated.

3.1.8 Flexible Pipe Connectors

Connectors shall be attached to components in strict accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the flexible pipe connector manufacturer and shall be provided at the intervals recommended.

3.1.9 Temperature Gauges

Temperature gauges shall be located on coolant supply and return piping at each heat exchanger, on condenser water piping entering and leaving a condenser, at each automatic temperature control device without an integral thermometer, and where indicated or required for proper operation of equipment. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 1 inch.

3.1.10 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as supplemented and modified in this specification section. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

3.1.10.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.1.10.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

3.1.10.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.1.10.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.1.10.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher. Type 40 shields shall be used on all piping less than 4 inches and all piping 4 inches and larger carrying medium less than 60 degrees F. A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 2 inches and larger.

3.1.10.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 50 pounds shall have the excess hanger loads suspended from panel points.

3.1.10.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 15 feet, not more than 8 feet from end of risers, and at vent terminations.

3.1.10.8 Pipe Guides

Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.1.10.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 4 inches and

larger, a Type 39 saddle shall be used. On piping under 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.1.10.10 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.1.10.11 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material used for support shall be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.1.11 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 5 feet on each side of each expansion joint, and in lines 4 inches or smaller not more than 2 feet on each side of the joint.

3.1.12 Pipe Anchors

Anchors shall be provided where indicated. Unless indicated otherwise, anchors shall comply with the requirements specified.Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required.

Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal.

3.1.13 Building Surface Penetrations

Sleeves shall not be installed in structural members except where indicated or approved. Except as indicated otherwise piping sleeves shall comply with requirements specified. Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A 653/A 653M, Coating Class G-90, 20 gauge. Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A 53/A 53M, Schedule 20. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 1/2 inch depth. Sleeves shall not be installed in structural members.

3.1.13.1 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of 1/4 inch all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07 92 00 JOINT SEALANTS.

3.1.13.2 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a .17 ounce copper sleeve, or a 0.032 inch thick aluminum sleeve, each within an integral skirt or flange.

Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 8 inches from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 2 inches above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

a. Waterproofing Clamping Flange: Pipes up to and including10 inches in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut.

   After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal rubber sealing elements to expand and provide a watertight seal between the pipe/conduit seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

3.1.13.3 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07 84 00 FIRESTOPPING.

3.1.13.4 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.1.14 Access Panels

Access panels shall be provided where indicated for all concealed valves, vents, controls, and additionally for items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05 50 00 METAL: MISCELLANEOUS AND FABRICATIONS.

3.2 ELECTRICAL INSTALLATION

Install electrical equipment in accordance with NFPA 70 and manufacturers instructions.

3.3 CLEANING AND ADJUSTING

Pipes shall be cleaned free of scale and thoroughly flushed of all foreign matter. A temporary bypass shall be provided for all water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from all water systems by operating the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed.

3.4 FIELD TESTS

Field tests shall be conducted in the presence of the QC Manager or his designated representative to verify systems compliance with specifications. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor.

3.4.1 Equipment and Component Isolation

Prior to testing, equipment and components that cannot withstand the tests shall be properly isolated.

3.4.2 Pressure Tests

Each piping system shall be hydrostatically tested at a pressure not less than 188 psig for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Test pressure shall be monitored by a currently calibrated test pressure gauge. Leaks shall be repaired and piping retested until test requirements are met. No leakage or reduction in gage pressure shall be allowed.

Leaks shall be repaired by rewelding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping shall be tested in place before concealing.

Submit for approval pressure tests reports covering the above specified piping pressure tests; describe the systems tested, test results, defects found and repaired, and signature of the pressure tests' director. Obtain approval from the QC Manager before concealing piping or applying insulation to tested and accepted piping.

3.4.3 Condenser Water Quality Test Reports

The condenser water system shall be analyzed by the water treatment company a minimum of once a month for a period of one year after system acceptance. Submit for approval the specified condenser water quality test reports. The analysis and resulting reports shall include the following information recorded in accordance with ASTM D 596.

Date of Sample	_____
Temperature	_____ degrees F.
Silica (SiO2)	_____ ppm (mg/1)
Insoluble	_____ ppm (mg/1)
Iron and Aluminum Oxides	_____ ppm (mg/1)
Calcium (Ca)	_____ ppm (mg/1)
Magnesium (Mg)	_____ ppm (mg/1)
Sodium and Potassium (Na and K)	_____ ppm (mg/1)
Carbonate (HCO3)	_____ ppm (mg/1)
Sulfate (SO4)	_____ ppm (mg/1)
Chloride (Cl)	_____ ppm (mg/1)
Nitrate (NO3)	_____ ppm (mg/1)
Turbidity	_____ unit
pH	_____
Residual Chlorine	_____ ppm (mg/1)
Total Alkalinity	_____ epm (meq/1)
Non-Carbonate Hardness	_____ epm (meq/1)
Total Hardness	_____ epm (meq/1)
Dissolved Solids	_____ ppm (mg/1)
Fluorine	_____ ppm (mg/1)
Conductivity	_____ micrmho/cm

3.4.4 Related Field Inspections and Testing

3.4.4.1 Piping Welds

Examination of Piping Welds is specified in the paragraph above entitled "Examination of Piping Welds".

3.4.4.2 HVAC TAB

Requirements for testing, adjusting, and balancing (TAB) of HVAC water piping, and associated equipment is specified in Section 23 05 93.00 10 TESTING,ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.5 INSTRUCTION TO GOVERNMENT PERSONNEL

Furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the chilled water, chilled-hot water, and condenser water piping systems. Instructors shall be thoroughly familiar with all parts of the installation and shall be instructed in operating theory as well as practical operation and maintenance work. Submit a lesson plan for the instruction course for

approval. The lesson plan and instruction course shall be based on the approved operation and maintenance data and maintenance manuals.

Conduct a training course for the operating staff and maintenance staff selected by the Contracting Officer. Give the instruction during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be one man-day.. Use approximately half of the time for classroom instruction and the other time for instruction at the location of equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

3.6 ONE-YEAR INSPECTION REPORT FOR COOLING WATER

At the conclusion of the one year period, each connecting cooling tower and liquid chiller condenser inspect for problems due to corrosion, scale, and biological growth. If the equipment is found not to conform to the manufacturers recommended conditions, and the water treatment company recommendations have been followed; the water treatment company shall provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations.

-- End of Section --

SECTION 23 65 00.00 10

COOLING TOWER

(AM #3)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S1.13	(1995; R 1999) Methods for the Measurement of Sound Pressure Levels in Air (ASA 118)

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2005) Safety in Welding, Cutting and Allied Processes

ASME INTERNATIONAL (ASME)

ASME PTC 23	(2003) Atmospheric Water Cooling Equipment

ASTM INTERNATIONAL (ASTM)

ASTM B 117	(2007a) Standing Practice for Operating Salt Spray (Fog) Apparatus
ASTM D 1784	(2007) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D 520	(2000; R 2005) Zinc Dust Pigment
ASTM E 84	(2008a) Standard Test Method for Surface Burning Characteristics of Building Materials

COOLING TECHNOLOGY INSTITUTE (CTI)

CTI ATC-105	(2000) Acceptance Test Code
CTI Std-111	(1998) Gear Speed Reducers
CTI Std-137	(2003) Fiberglass Pultruded Structural Products for Use in Cooling Towers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2007) Standard for Motors and Generators

NEMA MG 2	(2001) Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 214	(2005) Water-Cooling Towers
NFPA 255	(2005; Errata 2006) Standard Method of Test of Surface Burning Characteristics of Building Materials

1.2 PROJECT REQUIREMENTS

1.2.1 Safety

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded or fitted with other types of safety devices. Install safety devices so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1. Provide catwalk, ladder, or guardrail where indicated and in accordance with Section 05 50 00 METAL: MISCELLANEOUS AND FABRICATIONS.

1.2.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Cooling Tower; G, DO

Manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and fan curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Posted Instructions

Posted instructions, at least 2 weeks prior to construction completion, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

Performance Tests; G, DO

A schedule, at least 2 weeks prior to the start of the cooling tower performance tests which identifies the proposed date, time, and location for the tests.

Demonstrations

A schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

Verification of Dimensions

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

SD-06 Test Reports

Performance Tests

Six copies of the report provided in bound 8 1/2 x 11 inch booklets. The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall document all phases of tests performed as well as conclusions as to the adequacy of the system (including sound performance). The report shall include performance curves which show selection points and predicted performance. The report shall include initial test summaries, all repairs/adjustments made, and the final test results.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, DO

Six complete copies of the manual in bound 8 1/2 x 11 inch booklets. List step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Provide spare parts data for each different item of equipment. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts

recommended by the manufacturer to be replace on a routine basis.

List routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

A certified list of qualified permanent service organizations, which includes their addresses and qualifications, for support of the equipment. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market. Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products shall be supported by a service organization.

2.2 NAMEPLATES

Major equipment including cooling towers, cooling tower gear drive assemblies, fans, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of anodized aluminum. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics shall be as shown, and unless otherwise indicated, all motors of 1 horsepower and above with open, dripproof, totally enclosed, or explosion proof fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to

NEMA MG 1 and NEMA MG 2 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors shall be sized for the applicable loads. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

(AM #3)

2.3.1 Electrical

Single Electrical Connection terminal box shall be wired for operation and provided by manufacturer. A single-pole, double-throw vibration limit switch in a NEMA 4 housing shall be installed on the mechanical equipment support for wiring into the owner's control panel. The purpose of this switch will be to interrupt power to the motor in the event of excessive vibration. It shall be adjustable for sensitivity, and shall require manual reset.

The fluid cooler shall be equipped with a UL 508 control system in a NEMA 12 indoor or NEMA 3R outdoor enclosure capable of controlling motors as required, and designed specifically for fluid cooler applications. The panels shall be provided; one for each of two cells and shall include a main circuit breaker disconnect with an external operating handle, lockable in the off position for safety and solid state temperature controller. Door mounted selector switches shall be provided to enable automatic or manual control and wired for 120VAC control. Control circuit to be wired out to terminal blocks for one field connection to remote vibration switches, sump pumps, fans, and sump heaters.

The temperature controller shall be adjustable for the required process temperature. The temperature controller will display two temperatures, one for process temperature and the other for set point. Water temperature input shall be obtained using a thermal sensing device on the process coil and wired back to the solid state temperature controller in the VFD control panel. (AM #3)

2.4 COOLING TOWER MATERIALS

(AM #3)

2.4.1 Fluid Cooler

Except where otherwise specified, all components of the fluid cooler shall be fabricated of heavy-gauge steel, protected against corrosion by G-235 galvanizing. After passivation of the galvanized steel (8 weeks at pH 7-8, and calcium hardness and alkalinity at 100-300 ppm each), the fluid cooler shall be capable of withstanding water having a pH of 6.5 to 9.0; a chloride content up to 500 ppm as NaCl (300 ppm as Cl-); a sulfate content (as SO4) up to 250 ppm; a calcium content (as CaCO3) up to 500 ppm; silica (as SiO2) up to 150 ppm; and design operating ranges up to 50°F (27.8°C).

The circulating water shall contain no oil, grease, fatty acids, or organic solvents.

Furnish and install an induced-draft, crossflow-type, factory assembled, galvanized steel, closed circuit fluid cooler. Unit shall consist of 2 cell(s), as shown on plans. The limiting overall dimensions of the fluid cooler shall be 12 ft wide, 40 ft long, and 20 ft high to the top of the fan guard. Total operating power of all fans shall not exceed 60 Hp. Combined capacity of all motors per cell shall not exceed 30 Hp.

The structure and anchorage shall be designed to withstand a wind load of 20 psf (960 Pa) on single-flow models and 30 psf (1440 Pa) on double-flow models, as well as .4g seismic load while operating. The fluid cooler shall be designed to withstand shipping and hoisting loads of 2g horizontal or 3g vertical. The fan deck and hot water basin covers on double-flow models shall be designed for 50 psf (2.42 kPa) live load or a 200 lb (91 kg) concentrated load. Handrails, where specified, shall be capable of withstanding a 200 lb (890N) concentrated live load in any direction, and shall be designed in accordance with OSHA guidelines.
Thermal Performance:

The fluid cooler shall be capable of cooling 905 gpm of water from 97 °F to 82 °F at a design entering air wet-bulb temperature of 77 °F. Coil pressure drop shall not exceed 8.0445 psi. The thermal performance rating shall be Certified by the Cooling Technology Institute.
(AM #3)

2.4.2 Fiberglass Reinforced Plastic (FRP)

FRP components shall be inert, corrosion resistant, and fire-retardant with a thickness of 12 ounces per square foot. FRP components shall contain an ultraviolet (UV) ray inhibitor as per CTI Std-137, Grade 1 or 3.

2.4.3 Polyvinyl Chloride (PVC) Formed Sheets

ASTM D 1784, Type I, Grade 1 with a flame spread rating of 25 or less per ASTM E 84.

2.4.4 Concrete

Concrete shall conform to Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE. Exposed concrete shall be rub-finished for smooth and uniform surfaces free of form marks and defects. Honeycomb concrete shall not be permitted.

2.4.5 Hardware

Bolts shall be cadmium-plated, zinc-coated steel, or Type 304 stainless steel. Each bolt shall be provided with neoprene and cadmium-plated steel washers under the heads. Nails shall be silicon bronze, commercial bronze, or stainless steel. Hardware shall meet the salt-spray fog test as defined by ASTM B 117.

2.5 COOLING TOWER

2.5.1 Type

Tower shall be the induced mechanical draft type of the counterflow closed circuit fluid cooler design and shall be certified by the Cooling Tower

Institue (CTI). Factory fabricated, factory-assembled towers which are shipped to the job site in separate cells or modules shall be provided with all appropriate manufacturer's hardware for assembly in the field. Factory fabricated, field-assembled towers shall be assembled and adjusted at the job site by a factory representative.

2.5.2 Framework, Casing, and Supports

Towers shall be designed and constructed to withstand a wind pressure of not less than 30 pound-force per square foot (psf) on external surfaces. Framework, structural supports, and equipment supports shall be zinc-coated steel. Casing (exterior enclosing walls) shall be constructed of zinc-coated steel or FRP. Materials provided for framework, casings and equipment supports shall be compatible. Structural supports shall be provided in accordance with the recommendations of the manufacturer of the tower unless otherwise indicated.

2.5.3 Foundations

Cooling tower foundations shall meet the requirements of the cooling tower manufacturer and be as indicated. Foundation design shall be based on the load conditions and soil bearing value indicated. Foundation calculations shall be submitted with the equipment drawings.

2.5.4 Stairways and Ladders

Provide stairs, 60-degree ship ladders or straight-rung ladders of standard design, starting at ground level and extending as high as required to gain access to fan decks and water distribution systems. Stairways and ladders shall be hot-dip, zinc-coated steel. Ladders higher than 12 feet shall have a safety cage.

2.5.5 Handrailings

Steel handrailings shall be not less than 42 inches high around the exterior of each working surface that is 12 feet or more above the ground, roof, or other supporting construction. Railings shall be not smaller than 1-1/4 inch zinc-coated steel pipe with standard zinc-coated steel railing.

2.5.6 Access Doors

Each tower shall be provided with access doors at grade level to provide entry to the interior for service maintenance without removal of the fill. Doors shall be provided on each endwall of each cooling tower cell. Frame and brace access doors to prevent damage when opening and closing. Doors shall be located adjacent to float controls.

2.5.7 Louvers

Air inlets for each cooling tower shall be provided with individually removable louvers arranged to prevent the escape of water. Louvers shall be zinc-coated steel. Materials provided for casings and louvers shall be compatible; one material shall not produce stains upon the other. Air intakes shall be provided with 1 inch zinc-coated steel mesh.

2.5.8 Fan Deck and Cylinder

Each fan shall be mounted in a fan cylinder (or stack) to elevate the fan intake air. Total extension height shall not exceed the fan diameter.

Each fan cylinder shall be provided with a zinc-coated steel 12 gauge wire mesh securely mounted to the top of the cylinder in accordance with manufacturer's recommendations. Fan decks shall be designed to withstand a live load of not less than 60 psf in addition to the concentrated or distributed loads of equipment mounted on the fan decks. Fan deck and cylinders shall be constructed of zinc-coated steel, or FRP and be compatible with the entire tower construction.

2.5.9 Fans

Fans shall be the centrifugal or adjustable-pitch propeller type, constructed of zinc-coated steel, Type 304 stainless steel, aluminum or an aluminum alloy. Propeller type shall have a maximum tip speed of 10,800 fpm. Fan blade assembly shall be both statically and dynamically balanced after assembly of the cooling tower. Fan hub shall be constructed of a material compatible with fan blades with adequate surface protection against corrosion. Complete fan assembly (fan and mounting) shall be designed to give maximum fan efficiency and long life when handling saturated air at high velocities. Each cooling tower fan shall be provided with a ball and pedestal type vibration limit switch which shall stop the corresponding fan motor in the event of sensing excessive fan vibration.

(AM #3)
2.5.9.1 Fans

Fan(s) shall be heavy-duty, axial flow design. Fan(s) shall be driven through an industrial grade system of V-belts, pulleys, and tapered roller bearings. Bearings shall be rated at an L10 life of 40,000 hours, or greater.

Combined capacity of all fan motors per cell shall not exceed 30 Hp. Motor(s) shall be Totally Enclosed, 1.15 service factor, variable torque, and specially insulated for fluid cooler duty. Speed and electrical characteristics shall be 1800 rpm, single-winding, 3 phase, 60 hertz, 480 volts. (AM #3)

2.5.10 Speed Reducers Gears and Drive Shaft

Speed reducer gears shall be rated in accordance with CTI Std-111. Gear reducers shall be of the spiral or helical, double reduction type. Reducer shall be mounted in accordance with manufacturer's recommendations. Each reducer shall be provided with an oil level cutoff switch interlocked to the fan motor. Each reducer shall be provided with an oil level sight glass, fill, drain, and vent lines located in a readily accessible position. Drive shafts shall be the full floating type with flexible couplings at both ends and have a service factor of 1.0 or greater. Drive shafts shall be of stainless steel, fitted each end with flexible couplings (stainless steel plate type). Each drive shaft shall be provided with a galvanized steel guard, to prevent damage to surrounding equipment in case of shaft failure. Provision shall be made for lubrication of all bearings. Bearings shall be accessible to the extent that each bearing can be lubricated without dismantling fan.

2.5.11 Fan Motors

Each motor shall be a single speed, totally enclosed, insulation Class B, NEMA Design B, continuous-rated type which conforms to NEMA MG 1. Fan motors shall have totally enclosed enclosures and be located outside the discharge airstream. Motors shall be mounted according to manufacturer's

recommendations. Two-speed motors shall have a single winding with variable torque characteristics.

2.5.12 Variable Frequency Drives

Where variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use solid-state variable-speed controllers for motors rated 3.75 kW (10 hp) or less and adjustable frequency drives for larger motors.

2.5.13 Code Water Basin

Basin shall be completely watertight and constructed of zinc-coated steel Type 304 stainless steel or FRP. Basin shall be constructed and installed to ensure that air will not be entrained in outlets when operating and no water will overflow on shutdown. Each individual sump shall be provided with an individual outlet. Each outlet shall be provided with a 1/2 inch mesh, zinc-coated steel wire securely mounted to prevent trash from entering the outlet. Each basin shall be provided with overflow and valved drain connections. Each basin shall be provided with a float-controlled, makeup water valve as indicated. The makeup water shall discharge not less than 2 inches or two pipe diameters, whichever is greater, above the top of the basin.

(AM #3)
2.5.13.1 Sump Pumps

Two (2) 7.5 Hp Recirculation pump(s) shall be mounted one to each collection basin in conjunction with a suction assembly. The total power of all pumps shall not exceed 15Hp. Recirculation piping shall be schedule 40 PVC. A blowdown line with metering valve shall be connected directly to the fluid cooler overflow.(AM #3)

2.5.14 Electric Basin Heater

Heater shall be the electric immersion type with water-tight junction boxes mounted in the basin with sufficient capacity to maintain the basin water temperature above 40 degrees F at an ambient temperature of 25 degrees F. Heater shall be complete with control thermostat, transformer, contactor, and low water level heater protection.

2.5.15 Hot Water Distribution System

Water distribution shall be the pressurized-flow type system which distributes waters evenly over the entire fill surface. Each tower cell shall be designed so that a water flow of 140 percent capacity will not cause overflowing or splashing. The distribution system for each cell shall include adjustable flow control valves. The entire distribution system shall be self-draining and nonclogging. Piping shall be either cast iron, ductile iron, threaded-glass-fiber reinforced epoxy pipe, polypropylene, PVC or Schedule 80 black steel.

2.5.15.1 Pressurized-Flow System

System shall include piping, fittings, branches, and spray nozzles. Spray nozzles shall be stainless steel, bronze, polypropylene, or high-impact plastic. Nozzles shall be cleanable, nonclogging, removable, and spaced for even distribution.

2.5.15.2 Basin Cover

Hot water distribution basins shall be provided with the tower manufacturer's standard removable, zinc-coated steel, stainless steel or FRP covers. Covers shall prevent airborne debris from entering the basin.

2.5.16 Drift Eliminators

Eliminators shall be provided in the tower outlet to limit drift loss to not over 0.02 percent of the circulating water rate. Eliminators shall be constructed of polyvinyl chloride (PVC). Eliminators shall be of the multi-pass zigzag type, assembled into sections making a strong, stable unit. Eliminators sections shall be supported on PVC or FRP tee sections.

(AM #3)
2.5.17 Coil(s)

Coil(s) shall consist of fully welded box headers with serpentine coils and hot-dip galvanized after fabrication. Coils shall be tested to 400 psi (2757 kPa) air pressure while immersed in water. Maximum operating design pressure shall be 225 psi (1551 kPa). The coil shall be designed for free drainages of fluid at shutdown. (AM #3)

~~2.5.17 Fill (Heat Transfer Surface)~~

~~Tower fill shall be the film type. Fill material shall be free to expand or contract without warping or cracking. No plasticized wood cellulose shall be provided for fill material. Fill shall be removable or otherwise made accessible for cleaning. Space supports shall be corrosion resistant and shall prevent warping, sagging, misalignment, or vibration of the fill material. Fill material and supports shall be designed to provide for an even mixing of air and water. Fill material shall be constructed of PVC formed sheets in a pattern, and of sufficient height to meet the performance specifications.~~

2.5.18 Fire Safety

Towers shall conform to NFPA 214. Fire hazard rating for plastic impregnated materials shall not exceed 25. Plastics shall not drip or run during combustion. Fire hazard ratings shall be in accordance with ASTM E 84 or NFPA 255.

2.5.19 Noise Control

Sound power level data for the cooling tower shall be based on tests conducted in accordance with ANSI S1.13. Maximum acceptable noise limits for a cooling tower cell shall not exceed 80 db 5'-0" from the edge of the cooling tower fan.

2.6 FABRICATION

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B 117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch

mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

2.7 SUPPLEMENTAL COMPONENTS/SERVICES

2.7.1 Condenser Water Piping and Accessories

Condenser water piping and accessories shall be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.7.2 Water Treatment

Water treatment shall be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform verification of dimensions in the field, and advise the Contractor Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Work shall be performed in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance. Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions. Field painting is required for surfaces not otherwise specified, and finish painting of items only primed at the factory; paints are specified in Section 09 90 00 PAINTS AND COATINGS.

3.3 PERFORMANCE TESTS

After a cooling tower has been found acceptable under a visual and dimensional examination, a field performance test shall be performed in accordance with ASME PTC 23 or CTI ATC-105. The salt spray test is not required. The cooling tower test shall be performed in the presence of a Government representative. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. The services of a qualified technician shall be provided as required to perform all tests and procedures indicated herein. Field tests shall be coordinated with Section 23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.4 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension.

3.5 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 8 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

-- End of Section --

SECTION 23 82 19

FAN COIL UNITS
08/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S12.23	(1989; R 2006) Method for the Designation of Sound Power Emitted by Machinery and Equipment

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 440	(2005) Standard for Room Fan-Coils and Unit Ventilators

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1	(2003; Corrigendum 2005) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerance - International Restrictions

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2007) Standard for Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2008) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-810	(Rev F; Notice 3) Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests

UNDERWRITERS LABORATORIES (UL)

UL 1995	(2005) Standard for Heating and Cooling Equipment
UL Bld Mat Dir	(2009) Building Materials Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Submit Material, Equipment, and Product Installation Lists in accordance with paragraph entitled, "General Requirements," of this section.

SD-02 Shop Drawings

Submit Fabrication Drawings for fan coil units in accordance with paragraph entitled, "General Requirements," of this section.

Submit Installation Drawings for fan coil systems in accordance with the paragraph entitled, "Installation," of this section.

SD-03 Product Data

Submit Equipment and Performance Data for fan coil units in accordance with paragraph entitled, "General Requirements," of this section.

Submit the manufacturer's catalog data for the following items:

Coils; G, DO
Casing; G, DO
Enclosure; G, DO
Motors; G, DO
Fan; G, DO
Drain Pans; G, DO
Filters; G, DO
Controls; G, DO

SD-04 Samples

Submit the Manufacturer's Standard Color Chart for fan coil units in accordance with paragraph entitled, "General Requirements," of this section.

SD-07 Certificates

Submit the Listing of Product Installations for fan coil units in accordance with paragraph entitled, "Installation," of this section.

Submit the certificates for following items showing conformance with the referenced standards contained in this section.

Coils
Casing
Enclosure
Motors
Fan

Drain Pans
Filters
Controls

SD-10 Operation and Maintenance Data

Six complete copies of the manual in bound 8 1/2 x 11 inch booklets. List step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Provide spare parts data for each different item of equipment. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replace on a routine basis.

List routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

A certified list of qualified permanent service organizations, which includes their addresses and qualifications, for support of the equipment. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3 GENERAL REQUIREMENTS

Section 23 00 00 AIR SUPPLY, DISTRIBUTION, AND EXHAUST SYSTEMS applies to work specified in this section.

PART 2 PRODUCTS

2.1 GENERAL

Units shall include an enclosure for cabinet models and casing for concealed models.

Base unit shall be complete with galvanized casing, water-coil assembly with auxiliary water heating-coil, valve and piping package, drain pans, air filter, fan motor, and motor control. Sound-power-level, decibels reference, 10 to the minus 12 power watt, at the fan operating speed selected to meet the specified capacity, shall not exceed the following values at the midfrequency of each octave band:

	OCTAVE BANDS				
	3RD	4TH	5TH	6TH	7TH
Frequency (hertz)	250	500	1,000	2,000	4,000

	OCTAVE BANDS				
Power Level (decibels)	60	55	53	50	48

Obtain sound-power-level data or values for these units in accordance with the test procedures specified in ASA S12.23. Sound-power values apply to units provided with factory-fabricated cabinet enclosures and standard grilles. Values obtained for the standard cabinet models will be acceptable for concealed models without separate tests provided there is no variation between models as to the coil configuration, blowers, motor speeds, or relative arrangement of parts. Fasten each unit securely to the building structure. Capacity of the units shall be as indicated. Room fan-coil units shall be certified as complying with ARI 440 and shall meet the requirements of UL 1995.

2.2 ENCLOSURE

Construct enclosure of not lighter than 18-gage steel, properly reinforced and braced. Ensure front panel of enclosure is removable and provided with 1/2-inch thick insulation conforming to NFPA 90A, to prevent condensation. Ensure discharge louvers are four-way adjustable and designed to properly distribute air throughout the conditioned space. Ensure all ferrous-metal surfaces are galvanized or treated with a rust-inhibiting finish. Ensure all exposed-to-view enclosure corners and edges are rounded. Ensure discharge louvers are mounted in a top panel that is removable for coil cleaning. Ensure access doors are hinged and provided for all piping and control compartments. Ensure finish is in manufacturer's standard color as selected by the Contracting Officer.

2.3 CASING

Ensure casing is acoustically and thermally insulated internally with not less than 1/2-inch thick insulation conforming to NFPA 90A, fastened with waterproof and fire-resistant adhesive.

2.4 FAN

Ensure fan is galvanized steel or aluminum, centrifugal type with forward curved blades. In lieu of metal, fabricate or mold the wheels and scrolls from suitably reinforced nonmetallic compounds certified to have satisfactorily passed the low temperature, high temperature, temperature shock, and sand and dust tests for ground equipment, outlined in MIL-STD-810, without deformation, cracking, corrosion, or loss of balance characteristics. All surfaces shall be smooth. Ensure that assemblies are accessible for maintenance. Ensure that disassembly and reassembly is done by mechanical fastening devices, not adhesives. Dynamically and statically balance fan to ISO 1940-1 at the factory, after assembly in unit.

2.5 COILS

Construct the water coils of not less than 1/2-inch outside diameter (od) seamless copper tubing with copper or aluminum plate fins mechanically bonded or soldered to the tubes and provide with not less than 5/8-inch od female solder connectors, accessory piping package with terminal connections for control valves, and manual air vent on returns. Make provisions for coil removal.

2.6 DRAIN PANS

Size and locate drain pans to collect condensed water dripping from any item within the unit enclosure. Do not construct drain pans of lighter than 20-gage galvanized steel, thermally insulated to prevent condensation. Coat thermal insulation with a waterproofing compound. Not less than 3/4-inch National Pipe Thread (NPT) or 5/8-inch od copper drain connection shall be provided in the drain pan. Pans shall slope not less than 1/8-inch per foot to drain.

2.7 FILTERS

Provide filters for each unit that are glass fiber throwaway or permanent washable type, 1-inch nominal thickness, in conformance with UL Bld Mat Dir. Ensure filters are removable without tools.

2.8 MOTORS

Provide motors that are direct connected, two-bearing, permanent split-capacitor type with built-in overload protection, conform to NEMA MG 1, and mounted on a resilient base. Design motors for 1,060 revolutions per minute maximum on 115-volt, single-phase, 60-hertz power. Furnish motors with three built-in speeds, with four insulated leads (common, high, medium, and low) to terminate in a control-junction box.

Provide a solid-state variable speed controller capable of not less than 50 percent speed reduction in lieu of step speed control, when so specified.

2.9 CONTROLS

Applicable requirements of Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS shall apply.

Unit manufacturer shall factory-install control valves furnished by the automatic temperature-control manufacturer.

Install the controls in a unit-mounted control panel. Provide remote-mounted controllers where indicated.

Motor speed-control switch shall provide speed selection and off position and be mounted for convenient use from an access door.

2.10 INSULATION

Contain all thermal and acoustical insulation within a double walled enclosure or seal with a coating impervious to moisture.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment as indicated and specified and in accordance with manufacturer's recommendations. Set dampers in a fixed position to provide the outside air quantity scheduled.

Submit Installation Drawings for fan coil systems in accordance with referenced standards in this section.

3.2 TESTS

Hydrostatically test coils at 250 pounds per square inch (psi) or under water at 250 psi air pressure. Ensure the coils are suitable for 200-psi working pressure.

3.3 OPERATION AND MAINTENANCE

Contractor shall submit 6 copies of the Operation and Maintenance Manuals 30 calendar days prior to testing the fan coil units. Update and resubmit data for final approval no later than 30 calendar days prior to contract completion.

-- End of Section --

SECTION 25 08 10

UTILITY MONITORING AND CONTROL SYSTEM TESTING
04/06

PART 1 GENERAL

The purpose of this Specification is to define generic Factory, Performance Verification, and Endurance Test procedures for Utility Monitoring and Control Systems (UMCS) and building level DDC. These tests are to be used to assure that the physical and performance requirements of UMCS and building level DDC are tested, and that the test results are adequately documented. The Government will base certain contractual decisions on the results of these tests.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1B	(2002) Control Network Protocol Specification
CEA-709.3	(1999) Free-Topology Twisted-Pair Channel Specification
CEA-852-A	(2004) Tunneling Component Network Protocols Over Internet Protocol Channels

1.2 DEFINITIONS

1.2.1 Algorithm

A set of well-defined rules or procedures for solving a problem or providing an output from a specific set of inputs.

1.2.2 Analog

A continuously varying signal value (temperature current, velocity, etc.).

1.2.3 Analog to Digital (A/D) Converter

An A/D converter is a circuit or device whose input is information in analog form and whose output is the same information in digital form.

1.2.4 CEA-709.1B

"Control Network Protocol Specification", Standard communication protocol for networked control systems that provides peer-to-peer communications.

1.2.5 Application Specific Controller

A device that is furnished with a pre-established built in application that is configurable but not re-programmable.

1.2.6 Architecture

Architecture is the general organization and structure of hardware and software.

1.2.7 Binary

A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level.

1.2.8 Building Point of Connection (BPOC)

The point of connection between the UMCS network backbone and the building network backbone. The hardware at this location, which performs/provides the connection is referred to as the BPOC Hardware.

1.2.9 Control Wiring

This includes conduit, wire, and wiring devices to install complete HVAC control systems, including motor control circuits, interlocks, sensors, PE and EP switches, and like devices. This also includes all wiring from node to node, and nodes to all sensors and points defined in the I/O summary shown on drawings or specified herein, and required to execute the sequence of operation. Does not include line voltage power wiring.

1.2.10 Demand

The maximum rate of use of electrical energy averaged over a specific interval of time, usually expressed in kW.

1.2.11 Diagnostic Program

Machine-executable instructions used to detect and isolate system and component malfunctions.

1.2.12 Distributed Control

A system whereby all control processing is decentralized and independent of a central computer. In regards to a LonWorks based system, it also means where the control logic for a single piece of building level control resides in more than one controller (node).

1.2.13 Gateway

Text

1.2.14 Graphical User Interface (GUI)

Human-machine interfacing allows the operator to manage, command, monitor, and program the system.

1.2.15 Integration

Establishing communication between two or more systems to create a single system.

1.2.16 Interoperable

Two devices are interoperable if installed into the same system and they communicate with each other without the use of another device (such as a gateway).

1.2.17 LonTalk(r)

Open communication protocol developed by the Echelon(r) Corporation.

1.2.18 LONWORKS(r)

The communication technology developed by Echelon(r) Corporation for control systems developed. The technology is based on the CEA-709.1B protocol and employs interoperable devices along with the capability to openly manage these devices using a network configuration tool.

1.2.19 LONMARK(r) International (LONMARK(r) Interoperability Association)

Standards committee consisting of numerous independent product developers and systems integrators dedicated to determining and maintaining the interoperability guidelines for the LONWORKS(r) industry.

1.2.20 LonMarked(r)

A device that has been certified for compliance with LonMark(r) standards by the LonMark(r) International.

1.2.21 LONWORKS(r) Application Specific Controller (ASC)

A networked device or node that contains a complete, configurable application that is specific to a particular task.

1.2.22 LONWORKS(r) General Purpose Programmable Controller

A programmable control product, that unlike an ASC, is not installed with a fixed factory-installed application program. The application in the controller is custom software produced by the integrator specifically for the project.

1.2.23 LONWORKS(r) Network Services (LNS)

The database format for addressing nodes and variable bindings node-to-node.

1.2.24 Network

A system of distributed control units that are linked together on a communication bus. A network allows sharing of point information between all control units. Additionally, a network provides central monitoring and control of the entire system from any distributed control unit location.

1.2.25 Network Configuration Tool

Software used to create and modify the control network database and configure controllers.

1.2.26 Node ID

A unique 48-bit node identification (ID) tag given to each node by Echelon

Corporation.

1.2.27 Node

An intelligent LONWORKS(r) device with a node ID and communicates via CEA-709.1B and is connected to an CEA-709.1B network.

1.2.28 Operating System (OS)

Software which controls the execution of computer programs and which provides scheduling, debugging, input/output controls, accounting, compilation, storage assignment, data management, and related services.

1.2.29 Operator Workstation (OWS)

The OWS consists of a high-level processing desktop or laptop computer that provides a graphic user interface to network.

1.2.30 Peripheral

Input/Output (I/O) equipment used to communicate to and from the computer and make hard copies of system outputs and magnetic files.

1.2.31 Router

A device which routes messages destined for a node on another segment subnet or domain of the control network. The device controls message traffic based on node address and priority. Routers may also serve as communication links between powerline, twisted pair, fiber, coax, and RF media.

1.2.32 Standard Network Variable Type (SNVT)

A network variable of a standard format type used to define data information transmitted and receive by the individual nodes.

1.2.33 UMCS Network Media

Transmission equipment including cables and interface modules (excluding MODEMs) permitting transmission of digital information.

1.2.34 XIF

"External Interface File" contains the contents of the manufacturer's product documentation.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Factory Test; G, DO

After completing the test, the Contractor shall supply a factory

final, complete test report consisting of the following, as a minimum:

a. Section one of the submittal shall be a short summary of the factory test.

b. Section two of the submittal shall be a copy of the test plans.

c. Section three shall be the executed test procedure and shall be divided using tabs. Each tab section shall include all pertinent information pertaining to the executed and approved test, showing date and Government representative who witnessed/approved the test.

SD-06 Test Reports

UMCS and Building Level DDC Testing Sequence

The Contractor shall perform and document contractor field test on UMCS and building level DDC. The Contractor shall provide field test report prior to start of PVT and endurance testing.

Performance Verification Test; G, DO

After completing the test, the Contractor shall supply a fianl, complete PVT test report consisting of the following, as a minimum:

a. Section one of the submittal shall be a short summary of the performance verification test.

b. Section two of the submittal shall be a copy of the test plans.

c. Section three shall be the executed test procedure and shall be divided using tabs. Each tab section shall include all pertinent information pertaining to the executed and approved test, showing date and Government representative who witnessed/approved the test.

Endurance Testing

The Contractor shall provide UMCS Endurance Test Reports explaining in detail the nature of any failures, corrective action taken, and results of tests performed.

1.4 TEST DESCRIPTIONS

This document covers the factory, performance verification, and endurance test procedures for the Utility Monitoring and Control System (UMCS) and Direct Digital Control for HVAC. It has been written for a host based system where the LONWORKS(r) LNS database resides on the main computer (server) and communicates over the Ethernet (TCP/IP) connection to the field level controller nodes. The system shall be comprised of the server hardware and software, IP network hardware and software, and building point of connection (BPOC) hardware and software.

1.5 RELATED WORK

The contractor which provided building level DDC under Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS shall be responsible for testing the building level DDC. All control testing and controller tuning required under Section 23 09 23 must be completed and

approved before performing Performance Verification and Endurance Tests under this section.

1.6 RELATED SECTIONS

The following Sections: Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) and Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS must be part of the contract documents.

1.7 GENERAL REQUIREMENTS

1.7.1 Factory Test

The Contractor shall conduct a factory test at a company site. The Contractor shall perform some of the basic functions of the UMCS and building level DDC, to assure that the performance requirements of the specifications are met.

1.7.2 Performance Verification and Endurance Test

Performance Verification and Endurance Test shall:

a. Be conducted on hardware and software installed at the jobsite to assure that the physical and performance requirements of specifications are met. Tests on network media shall include all contractor furnished media and shall include at least one type of each device installed.

b. Be conducted under normal mode operation unless otherwise indicated in the initial conditions description for each test. System normal mode describes a condition in which the system is performing its assigned tasks in accordance with the contract requirements.

c. Utilize the operator workstation (OWS) to issue commands or verify status data.

1.8 TEST EQUIPMENT AND SETUP

All test equipment calibrations shall be traceable to NIST. The accuracy of the test equipment and overall test method shall be at least twice the maximum accuracy required for the test. For example, if a temperature sensor has an accuracy of +1 degree F over the executed range, the test instrument used shall have an accuracy of at least +0.5 degree F or better. All test equipment shall be provided by the Contractor unless otherwise noted in the contract documents.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 UMCS AND BUILDING LEVEL DDC TESTING SEQUENCE

The Contractor shall perform a successful factory test prior to start of installation work, as described in this section. During the installation phase, the Contractor shall perform all required field testing requirements on the UMCS and building level DDC as specified in Sections 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) and 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS, to verify that systems are functioning and installed per specifications. After completing all required field testing, the Contractor shall perform a successful PVT and

endurance test. All tests must be successfully completed, and test reports received, prior to final acceptance of the UMCS and building level DDC.

3.2 COORDINATION

The Contractor shall coordinate the testing schedule with the Government. Coordination shall include controls specified in other sections or divisions which include controls and control devices that are to be part of or interfaced to the UMCS specified in this section.

3.3 PROTECTION

The Contractor shall protect all work and material from damage by the work or workers, and shall be liable for all damage thus caused. The Contractor shall be responsible for the work and equipment until finally inspected, tested, and accepted. The Contractor shall protect the work against theft or damage, and shall carefully store material and equipment received onsite that is not immediately installed.

3.4 FACTORY TEST

3.4.1 Factory Test Plan

Prior to the scheduling of the factory tests, the Contractor shall provide the Government with a Factory Test Plan for approval, and receive notification of approval of the Test Plan and Procedures. The plan shall include the following, as a minimum:

a. System one-line block diagram of equipment used in the factory test model, indicating servers, workstations, peripherals, network equipment, controllers, and instrumentation.

b. System hardware description used in the factory test.

c. System software description used in the factory test.

d. Listing of control and status points in the factory test model; plus a table with the following information:

1) Input and output variables.
2) SNVTs for each variable.
3) Expected engineering units for each variable.
4) Node ID.
5) Domain & subnet addressing.

e. Required passwords for each operator access level.

f. List of other test equipment.

3.4.2 Test Procedures

The factory test procedures shall be developed from the generic test procedures in ATTACHMENT A. The test procedures shall consist of detailed instructions for test setup, execution, and evaluation of test results. The Contractor shall edit the generic test procedure for the provided UMCS and building level DDC. The Contractor shall perform a factory test on a model of the UMCS and building level DDC for the Government to verify the system will function to the requirements of the contract documents. The test architecture shall mimic a two building arrangement. There shall be a

TCP/IP layer with two Internet Protocol (IP) to Lon routers. Below each of the routers shall be both programmable (GPPC) and application-specific controllers (ASC). One server and one workstation with printers shall be connected to the IP layer. There shall be simulated input devices connected to controllers to enable the creation of changing variables. If, during testing, the system fails a portion of a test, the Government will inform the Contractor if the entire test or only the portion that failed must be re-performed. The Contractor shall give the Government a written report of those items which failed, what the problem was, and what was done to correct it. The Contractor shall provide onsite technical support to perform the PVT. ATTACHMENT A presents the generic Test Procedures with the following information:

a. Test identification number.

b. Test title.

c. Objective.

d. Initial conditions (if applicable).

e. Test equipment (if required).

f. Sequence of events.

g. Expected results.

3.5 FIELD TEST REQUIREMENTS

The UMCS contractor shall perform and document contractor start-up and field tests as required by Sections 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) and 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS. The field test validates that the UMCS and building level DDC are in operation without any problems or system errors prior to starting a PVT. The Contractor is required to validate that all software along with all hardware is installed to meet or exceed the contract document requirements. This includes all LONWORKS(r) networking and monitoring hardware and all peripherals associated with the network and hardware. Start-up and field testing must include:

a. Start-up Testing: All testing listed in Sections 25 10 10 and 23 09 23 shall be completed.

b. Point-to-Point Testing: All point-to-point testing of end field devices through proper input/output to graphic and operator interface shall be completed and approved.

c. All field calibration shall be completed and approved.

d. Detailed functional tests, verified by the Government that the system operation adheres to the Sequences of Operation.

e. Alarms and Interlocks: All alarm limits and testing shall be completed.

f. System schedules and setpoints: All schedule start/stops and system setpoints shall be entered, operating, and approved.

3.6 PERFORMANCE VERIFICATION TEST

3.6.1 Test Plan

Prior to the scheduling of the performance verification tests, the Contractor shall provide the Government with a Performance Verification and Endurance Test Plan and Procedures for approval, and receive notification of approval of the Test Plan and Procedures. The plan shall include the following, as a minimum:

a. Installed system one-line block diagram, indicating servers, workstations, peripherals, network equipment, controllers, and instrumentation.

b. Installed system hardware description.

c. Installed system software description, including any software revisions made since the factory test.

d. Listing of control and status points installed in the system; plus a table with the following information:

1). Input and output variables.
2). SNVTs for each variable.
3). Expected engineering units for each variable.
4). Node ID.
5). Domain & subnet addressing.

e. Required passwords for each operator access level.

f. List of other test equipment.

3.6.2 Test Procedures

The performance verification test procedures shall be developed from the generic test procedures in ATTACHMENT A. The test procedures shall consist of detailed instructions for test setup, execution, and evaluation of test results. The Contractor shall edit the generic test procedure for the provided UMCS and building level DDC. The Contractor shall perform a performance verification test (PVT) on the completed UMCS and building level DDC for the Government to verify the system is completely functional. If, during testing, the system fails a portion of a test, the Government shall inform the Contractor if the entire test or only the portion that failed must be re-performed. The Contractor shall give the Government a written report of those items which failed, what the problem was, and what was done to correct it. The contractor shall provide on-site technical support to perform the PVT. ATTACHMENT A presents the generic UMCS Performance Verification Test Procedures with the following information:

a. Test identification number.

b. Test title.

c. Objective.

d. Initial conditions (if applicable).

e. Test equipment (if required).

f. Sequence of events.

g. Expected results.

3.7 ENDURANCE TESTING

3.7.1 General

Endurance Test shall be designed to demonstrate the specified overall system reliability requirement of the completed system. The Endurance Test shall be conducted in four phases as described below. The Endurance Test shall not be started until the Government notifies the Contractor, in writing, that the Performance Verification Tests have been satisfactorily completed, training as specified has been completed, correction of all outstanding deficiencies has been satisfactorily completed, and that the Contractor has permission to start the Endurance Test. The Contractor shall provide an operator to man the system eight hours per day during first shift operations, including weekends and holidays, during Phase I and Phase III Endurance testing, in addition to any Government personnel that may be made available. The Government may terminate testing at any time if the system fails to perform as specified. Upon termination of testing by the Government or by the Contractor, the Contractor shall commence an assessment period as described for Phase II and Phase IV. Upon successful completion of the Endurance Test, the Contractor shall deliver test reports to the Government prior to acceptance of the system. The Contractor shall keep a record of the time and cause of each outage that takes place during the test period.

3.7.2 Phase I

During the Phase I testing, the system shall be operated as specified for 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays. The Contractor shall not make repairs during this phase of testing unless authorized by the Government, in writing. If the system experiences no failures during the Phase I test, the Contractor may proceed directly to Phase III testing, after the Contractor receives written permission from the Government.

3.7.3 Phase II

In Phase II, which occurs after the conclusion of Phase I, the Contractor shall identify all failures, shall determine the causes of all failures, repair all failures, and submit a test failure report to the Government. After submitting the written report, the Contractor shall convene a test review meeting at the job site to present the results and recommendations to the Government. The meeting shall be scheduled no earlier than five business days after receipt of the report by the Government. As a part of this test review meeting, the Contractor shall demonstrate that all failures have been corrected by performing appropriate Performance Verification Tests. Based on the Contractor's report, the test review meeting, and the Contractor's recommendation, the Government shall independently determine the restart point and may require that the Phase I test be totally or partially rerun. The Contractor shall not commence any required retesting until after receipt of written notification by the Government.

3.7.4 Phase III

After the conclusion of any retesting which the Government may require, the Phase II assessment shall be repeated as if Phase I had just been completed. If the retest is completed without any failures, the Contractor may proceed directly to Phase III testing, after the Contractor receives written permission from the Government. During Phase III testing, the system shall be operated as specified for 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays. The Contractor shall not make repairs during this phase of testing unless authorized by the Government, in writing.

3.7.5 Phase IV

In Phase IV, which occurs after the conclusion of Phase III, the Contractor shall identify all failures, determine the causes of all failures, repair all failures, and submit a test failure report to the Government. After submitting the written report, the Contractor shall convene a test review meeting at the job site to present the results and recommendations to the Government. The meeting shall not be scheduled earlier than five business days after receipt of the report by the Government. As a part of this test review meeting, the Contractor shall demonstrate that all failures have been corrected by performing appropriate Performance Verification Tests. Based on the Contractor's report, the test review meeting, and the Contractor's recommendation, the Government shall independently determine the restart point and may require that the Phase III test be totally or partially rerun. The Contractor shall not commence any required retesting until after receipt of written notification by the Government. After the conclusion of any retesting which the Government may require, the Phase IV assessment shall be repeated as if Phase III had just been completed. The Contractor shall not be held responsible for failures resulting from the following:

a. An outage of the main power supply in excess of the capability of any backup power source, provided that the automatic initiation of all backup sources was accomplished and that automatic shutdown and restart of the UMCS performed as specified.

b. Failure of a Government-furnished communications link, provided that the LON nodes and LON routers automatically and correctly operate in the stand-alone mode as specified, and that the failure was not due to contractor furnished equipment, installation, or software.

c. Failure of existing Government-owned equipment, provided that the failure was not due to contractor-furnished equipment, installation, or software.

3.7.6 Failure Reports

The Contractor shall provide UMCS Endurance Test Failure Reports. UMCS Test Failure Reports shall explain in detail the nature of each failure, corrective action taken, results of tests performed. If any failures occur during Phase I or Phase III testing, the Contractor shall recommend the point at which the Phase I or Phase III testing, as applicable, should be resumed.

3.8 ATTACHMENT A

TEST PROCEDURES

TITLE: Test Index
OBJECTIVE: The following is an index of tests.

NOTES: Tests one through twenty contain specific "item(s)" that apply to Sections 25 10 10 UTILITY MONITORING AND CONTROL SYSTEMS (UMCS) and 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING SYSTEMS. The following index of tests provides a summary of which "items numbers" apply to which specification.

Test No.	Test Title	Sect 25 10 10, UMCS	Sect 23 09 23, DDC for HVAC
One	Initial System Equipment Verification	Items 1 thru 15	Items 16 thru 32
Two	System Start-up	Items 1 thru 4	Items 5 and 6
Three	Monitor and Control Software	Items 1 thru 5	Not Applicable
Four	Graphic Display of Data	Items 1 thru 18	Not Applicable
Five	Graphic Navigation Scheme	Items 1 and 2	Not Applicable
Six	Command Functions	Items 1 thru 6	Not Applicable
Seven	Command Input Errors	Items 1 thru 6	Items 1 thru 6
Eight	Special Functions	Item 1	Not Applicable
Nine	Software Editing Tools	Items 1 thru 42	Items 1 thru 42
Ten	Scheduling	Items 1 thru 7	Items 8 thru 10
Eleven	Alarm function	Items 1 thru 15	Item 16
Twelve	Trending	Items 1 thru 8	Not Applicable
Thirteen	Demand Limiting	Items 1 thru 8	Not Applicable
Fourteen	Report Generation	Items 1 thru 6	Not Applicable
Fifteen	UPS Test	Items 1 thru 5	Not Applicable
Sixteen	EIA-709.1B to IP Router Test	Items 1 thru 3	Not Applicable
Seventeen	EIA-709.1B Router and Repeater	Not Applicable	Items 1 thru 4
Eighteen	EIA-709.1B Gateway Test	Items 1 thru 5	Items 1 thru 5
Nineteen	Local Display Panel	Not Applicable	Items 1 thru 5
Twenty	Network Configuration Tool	Items 1 thru 8	Items 1 thru 8

Test No.	Test Title	Sect 25 10 10, UMCS	Sect 23 09 23, DDC for HVAC
Twenty-One	Custom Tests	Item 1 and 2	Item 1 and 2

PVT Checklist

OBJECTIVE:

1. Inspect/test/verify that building-level DDC system is compliant with UFGS-23 09 23 and capable of integration with UMCS

INITIAL REQUIREMENTS/CONDITIONS

1. The following tests shall be completed and documentation shall be submitted by the contractor to the Government.

2. Date of Checklist: _____
3. Time of Checklist: _____
4. Contractor's Representative: _____
5. Government's Representative: _____

CHECKLIST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Draft or Final As-Built Drawings	Drawings submitted and approved	_____
		Point schedule(s) showing all required UMCS SNVTs submitted	_____
		Point schedules(s) showing device network addresses submitted	_____
		Local display panel (LDP) locations indicated on drawings submitted	_____
	Notes: _____		
2	Network Bandwidth Test Report	Test completed, accepted, and a report documenting results submitted	_____
	Notes: _____		
3	Programming software	Most recent version of the programming software for each type of GPPC has been submitted	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved
4	XIF Files	External interface files (XIF) files for each model of LONWORKS®-based DDC hardware has been submitted	_____
	Notes: _____		
5	LNS Database	Copies of the LNS database for the completed control network has been submitted	_____
	Notes: _____		
6	LNS Plug-in	LNS Plug-ins for each application specific controller has been submitted	_____
	Notes: _____		
7	Start-up testing report	Start-up has been successfully completed and testing report submitted	_____
		Controller tuning has been completed and document on point schedule	_____
		Calibration accuracy check completed and documented in test report	_____
		Actuator range check completed and documented in test report	_____
		Functional test to demonstrate control sequence completed and documented in test report	_____
	Notes: _____		
8	Software License	Software licenses received for all software on the project	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: One
TITLE: Initial System Equipment Verification

OBJECTIVE:

1. To verify that the hardware and software components of the system provided by the contractor are in accordance with the contract plans and specifications and all approved submittals.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Submit a detailed list of all approved hardware with Manufacturer, model number and location. This list is based on the contract plans, specifications, change orders (if any) and approved submittals which must be available for reference purposes during the test.

b. Submit a detailed list of all approved software with revision number and purpose of software. This list is based on the contract plans, specifications, change orders (if any) and approved submittals which must be available for reference purposes during the test.

2. Equipment

a. Verify all equipment is functional.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	The workstation hardware is installed and complies with specification paragraph titled "Workstation Hardware".	_____	_____
	Notes: _____		
2	The Server hardware is installed and complies with specification paragraph titled "Server Hardware".	_____	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved
3	The fiber optic patch panel is installed and complies with specification paragraph titled "Fiber Optic Patch Panel".	_____	_____
	Notes: _____		
4	The fiber optic media converter is installed and complies with specification paragraph titled "Fiber Optic Media Converter".	_____	_____
	Notes: _____		
5	The Ethernet switch is installed and complies with specification paragraph titled "Ethernet Switch".	_____	_____
	Notes: _____		
6	The IP router is installed and complies with specification paragraph titled "IP Router".	_____	_____
	Notes: _____		
7	The EIA-709.1B to IP router is installed and complies with specification paragraph titled "EIA-709.1B to IP Router".	_____	_____
	Notes: _____		
8	The EIA-709.1B gateway is installed and complies with specification paragraph titled "EIA-709.1B Gateway".	_____	_____
	Notes: _____		
9	The alarm printer is installed and complies with specification		

Item	Action Item	Expected Results	Approved
	paragraphs titled "PRINTERS" and "Alarm Printer".	_____	_____
	Notes: _____		
	_____		
10	The laser printer is installed and complies with specification paragraphs titled "PRINTERS" and "Laser Printer".	_____	_____
	Notes: _____		
	_____		
11	The color printer is installed and complies with specification paragraphs titled "PRINTERS" and "Color Printer".	_____	_____
	Notes: _____		
	_____		
12	The operating system is installed and complies with specification paragraph titled "Operating System (OS)".	_____	_____
	Notes: _____		
	_____		
13	The office automation software is installed and complies with specification paragraph titled "Office Automation Software".	_____	_____
	Notes: _____		
	_____		
14	The virus protection software is installed and complies with specification paragraph titled "Virus Protection Software".	_____	_____
	Notes: _____		
	_____		
15	The configuration server is installed and complies with specification paragraph titled "CEA-852-A Configuration Server".	_____	_____

Item	Action Item	Expected Results	Approved
	Notes: _____		
	_____		
DDC FOR HVAC			
16	The CEA-709.1B Router is installed and complies with specification paragraph titled "CEA-709.1B Router".	_____	_____
	Notes: _____		
	_____		
17	The CEA-709.3 Repeater is installed and complies with specification paragraph titled "CEA-709.3 Repeater".	_____	_____
	Notes: _____		
	_____		
18	The TP/FT-10 network is installed in accordance with CEA-709.3, with double-terminated bus topology.	_____	_____
	Notes: _____		
	_____		
19	Network wiring extends to the location of UMCS BPOC.	_____	_____
	Notes: _____		
	_____		
20	The Gateway is installed and complies with specification paragraph titled "Gateway".	_____	_____
	Notes: _____		
	_____		
21	All control valves are installed and comply with their associated specification paragraph under the section titled "Control Valves".	_____	_____
	Notes: _____		
	_____		
22	All dampers are installed and		

Item	Action Item	Expected Results	Approved
	comply with their associated specification paragraph under the section titled "Dampers".	_____	_____
	Notes: _____		
	_____		
23	All sensors are installed and comply with their associated specification paragraph under the section titled "Sensors".	_____	_____
	Notes: _____		
	_____		
24	All indicating devices are installed and comply with their associated specification paragraph under the section titled "Indicating Devices".	_____	_____
	Notes: _____		
	_____		
25	All user input devices are installed and comply with their associated specification paragraph under the section titled "User Input Devices".	_____	_____
	Notes: _____		
	_____		
26	All output devices are installed and comply with their associated specification paragraph under the section titled "Output Devices".	_____	_____
	Notes: _____		
	_____		
27	All multifunction devices are installed and comply with their associated specification paragraph under the section titled "Multifunction Devices".	_____	_____
	Notes: _____		
	_____		
28	All compressed air equipment is		

Item	Action Item	Expected Results	Approved
	installed and complies with their associated specification paragraph under the section titled "Compressed Air".	_____	_____
	Notes: _____		
	_____		
29	All ASCs are installed and comply with the specification paragraph titled "Application Specific Controller".	_____	_____
	Notes: _____		
	_____		
30	All LDPs and laptop computers are provided and comply with the specification paragraph titled "Local Display Panel".	_____	_____
	Notes: _____		
	_____		
31	All GPPCs are installed and comply with the specification paragraph titled "General Purpose Programmable Controller".	_____	_____
	Notes: _____		
	_____		
32	LNS-based system used to address nodes, bind variables, and LNS database of network exists on system.	_____	_____
	Notes: _____		
	_____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Two
TITLE: System Start-up

OBJECTIVE:

1. To validate that the system properly initializes and that the GUI properly reconnects to all communicating devices.
2. To validate that both application specific and programmable devices retain all vital information upon a power cycle.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Contractor shall provide a list of all software that will be used to verify point connection at field level controllers and user interface.

b. Contractor shall provide a list of all software need to verify application specific and programmable controller start-up.

2. Equipment

a. All peripherals and cables shall be connected per manufacturer's requirements.

b. The workstation shall be in the off mode.

c. All controls shall be fully functional and tested.

d. A programmable and application specific controller shall be randomly selected for the test.

3. Date of Test: _____
4. Time of Test: _____
5. Contractor's Representative: _____
6. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Energize the workstation.	The workstation will power-up and perform its start-up procedure without generating any errors or problems.	_____
	a) Operating system	Operating system shall be latest version of windows.	_____
	b) Start Network Configuration Tool.	The Network Configuration Tool drawing will open.	_____
	c) Start the System Plug-in.	The System plug-in will open.	_____
	d) Start the Server.	The Server will start.	_____
	e) Start the Workstation.	The Workstation will start. The operator shall now have the ability to view data from any device on the	

Item	Action Item	Expected Results	Approved
		network.	
	Notes:		
2	Check the communication from the server to the controllers.	Within the workstation software, when a device is selected, dynamic points lists become visible. Dynamic data represents success. A completion event failure message represents failure.	
	Notes:		
3	Verify on-line status.	All devices shall have on-line status indicated by the workstation software (green indicator).	
	Notes:		
4	View data from the graphical environment.	When a graphics page is opened, the points on the page should update. Question marks in lieu of data reflect failure.	
	Notes:		
DDC FOR HVAC			
5	Verify that configuration data in application specific controllers is written to EEPROM.	All configuration parameters should be accessible.	
	a) Open the LONWORKS® plug-in.	Software should open without errors.	
	b) Note several parameters such as temperature setpoints and flow settings.	Operator is able to view a sample of parameters (data values and setpoints).	
	c) Remove power from the controller for a minimum of 3 minutes.	Device should go off-line in Network Configuration Tool and workstation/server.	
	d) Replace power to the controller.	Device should return to on-line status.	
	e) Using the plug-in, verify that the parameters have not	Parameters shall not have changed.	

Item	Action Item	Expected Results	Approved
	changes.		
	Notes: _____		
	_____		
6	Verify that configuration data in programmable controllers is retained after a power cycle.	_____	_____
	a) From the Workstation view several configuration parameters and note the values.	Values of the parameters can be viewed from the tree structure.	_____
	b) Remove power for a minimum of 3 minutes.	Controller will go offline in workstation software.	_____
	c) Replace power to the controller.	Controller will return to online status.	_____
	d) From the Workstation view the same configuration parameters and note the values.	Parameters values shall not have changed.	_____
	Notes: _____		
	_____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Three
TITLE: Monitor and Control (M&C) Software Passwords

OBJECTIVE:

1. To validate that the system utilizes four basic password levels
2. To validate that each password level has the specified authority

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The Contractor shall provide documentation of M&C user password capacity in comparison with specification.

b. The Contractor shall provide a complete list of all users along with their passwords and user level prior to testing.

2. Equipment

a. Server and Workstation

3. Reference Documentation

a. Provide user manual documentation for setting up passwords

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Create password for new users.	New users shall exist in the server Database.	_____
	a) Set-up 4 users.	_____	_____
	b) Assign different levels to each.	_____	_____
	Notes: _____		
	_____		
2	Demonstrate level 1 authority.	_____	_____
	a) Sign in as the level 1 user.	Sign in shall be successful.	_____
	b) Attempt to view a system graphic.	Action shall be possible.	_____
	c) Attempt to acknowledge an alarm.	Action shall be denied.	_____
	d) Attempt to configure a trend.	Action shall be denied.	_____
	e) Attempt to configure a report.	Action shall be denied.	_____

Item	Action Item	Expected Results	Approved
	f) Attempt to override a point.	Action shall be denied.	_____
	g) Attempt to configure an alarm.	Action shall be denied.	_____
	h) Attempt to configure a schedule.	Action shall be denied.	_____
	i) Attempt to configure a demand limiting parameter.	Action shall be denied.	_____
	j) Attempt to modify a graphic page.	Action shall be denied.	_____
	k) Attempt to create a custom program.	Action shall be denied.	_____
	Notes: _____		
	_____		
3	Demonstrate level 2 authority.	_____	_____
	a) Sign in as the level 2 user.	Sign in shall be successful.	_____
	b) Attempt to view a system graphic.	Action shall be possible.	_____
	c) Attempt to acknowledge an alarm.	Action shall be possible.	_____
	d) Attempt to configure a trend.	Action shall be possible.	_____
	e) Attempt to configure a report.	Action shall be possible.	_____
	f) Attempt to override a point.	Action shall be denied.	_____
	g) Attempt to configure an alarm.	Action shall be denied.	_____
	h) Attempt to configure a schedule.	Action shall be denied.	_____
	i) Attempt to configure a demand limiting parameter.	Action shall be denied.	_____
	j) Attempt to modify a graphic page.	Action shall be denied.	_____
	k) Attempt to create a custom program.	Action shall be denied.	_____
	Notes: _____		
	_____		
4	Demonstrate level 3 authority.	_____	_____
	a) Sign in as the level 3 user.	Sign in shall be successful.	_____
	b) Attempt to view a system graphic.	Action shall be possible.	_____
	c) Attempt to acknowledge an alarm.	Action shall be possible.	_____
	d) Attempt to configure a	Action shall be possible.	

Item	Action Item	Expected Results	Approved
	trend.		
	e) Attempt to configure a report.	Action shall be possible.	
	f) Attempt to override a point.	Action shall be possible.	
	g) Attempt to configure an alarm.	Action shall be possible.	
	h) Attempt to configure a schedule.	Action shall be possible.	
	i) Attempt to configure a demand limiting parameter.	Action shall be possible.	
	j) Attempt to modify a graphic page.	Action shall be denied.	
	k) Attempt to create a custom program.	Action shall be denied.	
	Notes:		
5	Demonstrate level 4 authority.		
	a) Sign in as the level 3 user.	Sign in shall be successful.	
	b) Attempt to view a system graphic.	Action shall be possible.	
	c) Attempt to acknowledge an alarm.	Action shall be possible.	
	d) Attempt to configure a trend.	Action shall be possible.	
	e) Attempt to configure a report.	Action shall be possible.	
	f) Attempt to override a point.	Action shall be possible.	
	g) Attempt to configure an alarm.	Action shall be possible.	
	h) Attempt to configure a schedule.	Action shall be possible.	
	i) Attempt to configure a demand limiting parameter.	Action shall be possible.	
	j) Attempt to modify a graphic page program.	Action shall be possible.	
	k) Attempt to create a custom program.	Action shall be possible.	
	Notes:		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Four
TITLE: Graphic Display of Data

OBJECTIVE:

1. To validate that floor plans and equipment can be graphically displayed through GUI.
2. To validate the proper display of alarms on GUI.
3. To validate the proper display of trend data on GUI.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The contractor shall provide hard copies of "snap shots" of sample graphics pages prior to testing.

2. Equipment

a. The contractor shall have all graphics completed.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Notes

a. Different types of data and states should be clearly distinguishable from each other.

5. Date of Test: _____
6. Time of Test: _____
7. Contractor's Representative: _____
8. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
1	Demonstrate the use of a three dimensional representation of a mechanical system.	Equipment shall be represented in a three dimensional manner.	_____
	Notes: _____		
2	Demonstrate the presentation of real time data.	Dynamic real time data shall be presented on a graphics page.	_____
	Notes: _____		
3	Demonstrate the presentation of user	A user defined parameter such as a setpoint shall be	

Item	Action Item	Expected Results	Approved
	entered data.	presented on a graphics page. Different types of data and states should be clearly distinguishable from each other.	_____
	Notes: _____		
4	Demonstrate the presentation of a point in override.	An indication of override condition shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	_____
	Notes: _____		
5	Demonstrate the presentation of a device in the alarm state.	An indication of the alarm state shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	_____
	Notes: _____		
6	Demonstrate the presentation of data that is out of range.	An indication of out of range condition shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	_____
	Notes: _____		
7	Demonstrate the presentation of missing data (controller is offline).	An indication of missing data shall be viewable on the graphic page. Different types of data and states should be clearly distinguishable from each other.	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved
8	Demonstrate an error message when the operator attempts to execute in improper command.	An error message shall be displayed.	_____
	Notes: _____		
9	Demonstrate point and click access to context sensitive help.	Operator shall be able to easily access context sensitive help using the mouse.	_____
	Notes: _____		
10	Demonstrate point and click access to an engineering diagram.	Operator shall be able to access an engineering diagram using the mouse.	_____
	Notes: _____		
11	Demonstrate the creation of an engineering diagram.	Operator shall be able to create an engineering diagram.	_____
	Notes: _____		
12	Demonstrate the printing of a prepared report.	Operator shall be able to print a report using the mouse.	_____
	Notes: _____		
13	Demonstrate the display of one or more points.	Operator shall be able to request the display of one or more points.	_____
	Notes: _____		
14	Demonstrate the operator override of a point.	Operator shall be able to override a point.	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved
15	Demonstrate the modification of a time schedule.	Operator shall be able to modify a time schedule.	_____
	Notes: _____		
16	Demonstrate the execution of a report.	Operator shall be able to initiate a report.	_____
	Notes: _____		
17	Demonstrate the presentation of an alarm to include:	Operator shall be able to view an alarm with all of the required data.	_____
	a) Identification	_____	_____
	b) Date and time	_____	_____
	c) Alarm Type	_____	_____
	d) Set Points	_____	_____
	e) Units	_____	_____
	f) Current Value	_____	_____
	g) Priority	_____	_____
	h) Associated message & Secondary message	_____	_____
	Notes: _____		
18	Demonstrate the presentation of real time trend data.	Operator shall be able to view real time trend data as a function of time.	_____
	Notes: _____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Five
TITLE: Graphic Navigation Scheme

OBJECTIVE:

1. To validate hierarchical graphic displays from main screen to end devices.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The contractor shall provide a hierarchical block diagram of the system network prior to testing.

2. Equipment

a. The contractor shall have all programming completed to demonstrate graphic display.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Demonstrate the creation of a hierarchical tree structure for the presentation of point data with at least five levels.	Operator shall be able to organize point data graphic display in a hierarchical tree structure based on any organization desired. A typical organization could be: - Installation - Building - Building sub area - Main System-Unit - Terminal Unit	_____
	Notes: _____		
2	Demonstrate the creation of a hierarchical navigation structure for the graphic pages.	Operator shall be able or organize the graphical navigation from page to page using any hierarchical structure desired.	

Item	Action Item	Expected Results	Approved
		Examples: Home page to building 1 Building 1 to AHU 1 Building 1 back to Home Page Building 1 to 1st Floor Plan AHU 1 back to Building 1 AHU 1 back to Home Page AHU 1 to Terminal Unit Summary 1st Floor Plan back to Building 1 1st Floor Plan back to Home Page 1st Floor Plan to Any Terminal Device Terminal Unit Summary back to AHU 1 Terminal Unit Summary back to Building 1 Terminal Unit Summary back to Home Page Terminal Unit Summary to Individual Device	_____

Notes: _____

_____

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Six
TITLE: Command Functions

OBJECTIVE:

1. To demonstrate the functionality and ability to execute command to the end devices.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The Contractor shall provide documentation of all command functions prior to testing.

2. Equipment

a. The contractor shall have all command functions programmed and functional.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	From the tree structure, modify a parameter such as a set point.	The modified value shall be downloaded to the controller without delay and the controller performance shall be viewable by the monitoring of other dynamic points.	_____
	Notes: _____		
2	From a graphic page, modify a parameter such as a set point.	The modified value shall be downloaded to the controller without delay and the controller performance shall be viewable by the monitoring of dynamic points.	_____
	Notes: _____		
3	From the tree structure,	The analog output point	

Item	Action Item	Expected Results	Approved
	place an analog output point under operator override and assign a fixed value.	shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	_____
	Notes: _____		
4	From a graphic page, place an analog output point under operator override and assign a fixed value.	The analog output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	_____
	Notes: _____		
5	From the tree structure, place a digital output point under operator override and assign a fixed value.	The digital output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	_____
	Notes: _____		
6	From a graphic page, place a digital output point under operator override and assign a fixed value.	The digital output point shall accept the assigned value and ignore changes from application logic until the point is taken out of override.	_____
	Notes: _____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Seven
TITLE: Command Input Errors

OBJECTIVE:

1. To validate that the system ensures the necessary authority for command inputs
2. To validate that the system can control the range of command input values

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The contractor shall provide all command input error messages prior to testing.

2. Equipment

a. UMCS and DDC hardware and software

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Login using a password with point command. Notes: _____	Login occurs.	_____
2	Request a display of a SNVT. Notes: _____	The system displays the controllers SNVT value.	_____
3	Override the SNVT point to a selected value. Notes: _____	The SNVT value override changes the value in the controller.	_____

Item	Action Item	Expected Results	Approved
4	Release the override of a SNVT.	The SNVT value returns to normal.	_____
	Notes: _____		
5	For an nvi to a controller with a limit of 50 to 80, command the nvi to a value of 90.	The value will go the maximum of 80.	_____
	Notes: _____		
6	For an nvi to a controller for which the operator only has read privileges, command the nvi to a value of 90.	The operator will be denied the ability to command the nvi to any value.	_____
	Notes: _____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Eight
TITLE: Special Functions

OBJECTIVE:

1. Verify system has special integration as defined.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The Contractor shall provide documentation of all integrations prior to testing.

2. Equipment

a. The contractor shall have all UMCS and DDC hardware and software programmed, integrated, and completed.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Verify that a building that uses controls from a vendor other than the one being installed can be integrated into the GUI without any loss of functionality. (A simulated building will be set up using an IP-L router and controllers from Honeywell, TAC, Trane, etc.)	Data from the other vendors controllers shall be integrated into the GUI and the same functionality that would exist if the controllers were from the same manufacture shall exist.	_____

Notes: _____

_____

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Nine
TITLE: Software editing tools

OBJECTIVE:

1. To validate the performance of the M & C application programming tool for the GPPC.
2. To validate the performance of the display editing tool.
3. To validate the performance of the report generation display tool.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The contractor shall provide documentation and a backup softcopy of the editing tool prior to testing.

b. The contactor shall provide documentation of any future software upgrade versions that pertain to the software-editing tool.

2. Equipment

a. The contractor shall have working knowledge of the full capability of the software-editing tool.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS and DDC for HVAC			
1	Demonstrate the programming of an override function in a GPPC.	Operator shall be able to use the programmed function to override an output point in a GPPC.	_____
	Notes: _____		
2	Demonstrate software that enables the monitoring of data from a GPPC.	Operator shall be able to monitor points from a GPPC.	_____
	Notes: _____		
3	Demonstrate timer	Control logic shall honor	

Item	Action Item	Expected Results	Approved
	functions within applications of GPPC.	the built in timers.	_____
	a) delay on	_____	_____
	b) delay off	_____	_____
	c) one second delays	_____	_____
	d) interval timers	_____	_____
	Notes: _____		
4	Demonstrate logic loops ("for" and "while") in GPPC.	Control logic shall honor the criteria.	_____
	Notes: _____		
5	Demonstrate if-then-else logic in GPPC.	Control logic shall properly follow the if, then, else requirements.	_____
	Notes: _____		
6	Demonstrate basic math functions in GPPC.	Control logic shall properly execute math functions.	_____
	Notes: _____		
7	Demonstrate Boolean math functions in GPPC.	Control logic shall properly execute the functions.	_____
	Notes: _____		
8	Demonstrate exponential math functions in GPPC.	Control logic shall properly execute the functions.	_____
	Notes: _____		
9	Demonstrate trigonometric math functions in GPPC.	Control logic shall properly execute the functions.	_____
	Notes: _____		
10	Demonstrate bitwise math functions in GPPC.	Control logic shall properly execute the functions.	_____

Item	Action Item	Expected Results	Approved
	Notes: _____		
11	Create a user defined subroutine/function in GPPC.	Subroutine/function shall work correctly and be easily reused.	_____
	Notes: _____		
12	Create alarm conditions in GPPC.	Alarm variables shall be created according to the criteria.	_____
	Notes: _____		
13	Create and save a graphic symbol at the server.	Symbol shall be reusable on a new graphic.	_____
	Notes: _____		
14	Modify a graphic symbol at the server.	Operator shall be able to open an existing symbol and make changes.	_____
	Notes: _____		
15	Save a graphic symbol to a library at the server.	Symbol shall be available from the library for reuse.	_____
	Notes: _____		
16	Delete a graphic symbol at the server.	Symbol shall no longer exist for use.	_____
	Notes: _____		
17	Place a graphic symbol on a new graphic page at server.	When the new page is opened, the symbol shall be there.	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved
18	Associate particular conditions with particular displays at the server.	When the conditional variable changes, the display should change.	_____
	Notes: _____		
19	Overlay alphanumeric text on a graphic at the server.	Text shall properly display.	_____
	Notes: _____		
20	Create a new graphic from an old one at the server.	New graphic shall properly display.	_____
	Notes: _____		
21	Place dynamic data on a graphic at the server.	The dynamic data shall be viewable on the graphic.	_____
	Notes: _____		
22	Define the background color of a new graphic at the server.	The new graphic shall show the selected background color.	_____
	Notes: _____		
23	Define a foreground color for an element on a graphic to distinguish it from the background color at the server.	The color of the dynamic data that uses the foreground color shall display in the foreground color.	_____
	Notes: _____		
24	Position a symbol on a graphic at the server.	The operator shall be able to place a symbol at any location on a graphic.	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved
25	Position and edit alphanumeric descriptors at the server. Notes: _____	The alphanumeric display shall be as designed.	_____
26	Draw lines on a graphic at the server. Notes: _____	Lines shall display as drawn.	_____
27	Associate source of dynamic data for presentation on a graphic at the server. Notes: _____	Correct data shall be displayed.	_____
28	Display analog data on a graphic page at the server. Notes: _____	Correct data shall be displayed.	_____
29	Demonstrate the movement of the curser (crosshairs) by the use of the mouse at the server. Notes: _____	Crosshairs shall follow the commands from the mouse.	_____
30	Demonstrate the simultaneous use of multiple graphics (coincident graphics)at the server. Notes: _____	Operator shall see the use of the tile function and the use of the tab function to manage multiple graphics.	_____
31	Associate graphic properties such as color with the values from dynamic variables at	Graphic properties shall change as the value of the dynamic variable changes.	

Item	Action Item	Expected Results	Approved
	the server.		
	Notes: _____		
32	Create conditional displays based on the value of a dynamic variable at the server.	The graphic display shall change as the dynamic variable changes.	
	Notes: _____		
33	Review the standard symbol library at the	Operator shall see how to access symbols from the standard symbol library.	
	Notes: _____		
34	Demonstrate how to move data from the database to a report at the server.	The executed report shall contain data from the database.	
	Notes: _____		
35	Add comments and headers to a report at the server.	The executed report shall contain the comments and headers.	
	Notes: _____		
36	Demonstrate the time stamping of data in a report at the server.	Data presented in a report shall include the date and time the data was sampled.	
	Notes: _____		
37	Demonstrate the time stamping of the report generation at the server.	A report shall include the date and time it executed.	
	Notes: _____		
38	Demonstrate basic mathematical manipulation	Report shall display the results of the mathematical	

Item	Action Item	Expected Results	Approved
	of data within a report (daily averages, highs, lows, etc.) at the server.	manipulations.	_____
	Notes: _____		
39	Demonstrate the operator's ability to select either automatic or manual generation of a report.	Reports shall execute per the operator's instructions. Report one shall execute per the operator's instructions. Report two shall execute automatically on a time basis per operator's instructions.	_____
	Notes: _____		
40	Demonstrate the selection of either display, print to printer or print to file.	Reports shall execute per the operator's instructions. Report one is printed to printer. Report two is printed to file.	_____
	Notes: _____		
41	Demonstrate how a modified application program is imported into the server database for presentation to the workstations.	Modified list of variables shall be available from a workstation.	_____
	Notes: _____		
42	Demonstrate how a new device is added to the server database for presentation to the workstations.	New list of variables from the new device shall be available from a workstation.	_____
	Notes: _____		

End of Test

Item	Action Item	Expected Results	Approved

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Ten
TITLE: Scheduling

OBJECTIVE:

1. Verify that M&C software has ability to operate end devices off a time of day schedule utilizing defined parameters.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The contractor shall provide documentation of the minimum programmable schedules in comparison to the specification requirement prior to testing.

b. The contractor shall provide documentation of all schedules programmed in the UMCS prior to testing.

c. The contractor shall provide a trend or report log of all equipment on a schedule prior to testing.

2. Equipment

a. The contractor shall have GPPC and ASC with all scheduling completed for testing.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Demonstrate the basic functionality of a time schedule by monitoring the value of SNVT_occupancy as the time changes through a start time or a stop time.	The value of SNVT_occupancy shall properly track the time schedule.	_____
	Notes: _____		
2	Setup a weekly time schedule for a demo system with independent times for each day of the	Scheduling software shall accommodate the described requirements.	

Item	Action Item	Expected Results	Approved
	week and with up to 6 events per day.		_____
	Notes: _____		
	_____		
3	Setup a special event or date specific time schedule and verify that this schedule takes precedence over the weekly schedule.	The special event schedule shall take precedence.	_____
	Notes: _____		
	_____		
4	Setup a group time schedule for a collection of systems. This group schedule shall take precedence over the individual time schedules.	The group schedule shall take precedence.	_____
	Notes: _____		
	_____		
5	Demonstrate operator access to a time schedule from a graphic page.	Operator shall be able to access the time scheduling editor from a graphic page.	_____
	Notes: _____		
	_____		
6	Display the current date and time on a graphic page.	Operator shall be able to view the current date and time from a graphic page.	_____
	Notes: _____		
	_____		
7	Demonstrate automatic daylight savings time adjustment.	Time of day shifts automatically.	_____
	Notes: _____		
	_____		
HVAC			
8	Demonstrate the ability of GPPC to accept an occupied, unoccupied and	Equipment shall change modes based on the UMCS or from "system scheduler"	

Item	Action Item	Expected Results	Approved
	standby command from the UMCS.	SNVT schedule data.	_____
	Notes: _____		
	_____		
9	Demonstrate the ability of ASC to accept an occupied, unoccupied and standby command from the UMCS.	Equipment shall change modes based on the UMCS SVNT schedule data.	_____
	Notes: _____		
	_____		
10	Demonstrate use of the default schedule when communication is lost to the UMCS.	Equipment should use the default schedule until communication is reestablished.	_____
	Notes: _____		
	_____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Eleven
TITLE: Alarm Function

OBJECTIVE:

1. Verify M&C software is capable of alarm notification and routing.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The contractor shall provide documentation of alarm managing capacity in caparison with specification.

b. The contractor shall provide documentation of all alarm types and priorities utilized in the M&C prior to testing.

c. The contractor shall provide documentation of the alarm routing in this particular M&C.

2. Equipment

a. The contractor shall provide GPPC and ASC will alarms programmed.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Initiate a basic binary alarm condition such as a fan fail to start.	The nvo (SNVT) displayed on designated server/workstation shall change from a value of 0 to a value of 1. The alarm shall be presented in the alarm window. The alarm shall define the source of the alarm. The alarm shall define the time of the alarm. The alarm shall present its assigned priority. The alarm shall display a text message.	_____

Item	Action Item	Expected Results	Approved
	Notes: _____		
	_____		
2	Demonstrate the capability of associating a secondary text message with the alarm.	With a simple point and click, the operator shall have access to the secondary text message.	_____
	Notes: _____		
	_____		
3	Acknowledge the alarm.	The status of the alarm shall changed to acknowledged. The user that acknowledged the alarm shall be recorded along with the date and time of the action.	_____
	Notes: _____		
	_____		
4	Demonstrate the "pop up" of the alarm window when an alarm occurs.	When the alarm occurs, the alarm window shall automatically open.	_____
	Notes: _____		
	_____		
5	Demonstrate the capability to send a numeric page when an alarm occurs.	The numeric page is received.	_____
	Notes: _____		
	_____		
6	Demonstrate the capability to send an email when an alarm occurs.	The email shall be received.	_____
	Notes: _____		
	_____		
7	Demonstrate the printing of an alarm on the alarm printer.	The printer shall print the alarm.	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved
8	Identify the file on the hard disk that contains all of the alarms.	Opening the file shall display a list of all of the alarms.	_____
	Notes: _____		
9	Execute a user sort on the alarm file.	The presentation shall follow the defined sort.	_____
	Notes: _____		
10	Print the alarm file.	Paper copy shall be printed.	_____
	Notes: _____		
11	Take an application specific controller off-line.	An alarm should be generated.	_____
	Notes: _____		
12	Take a programmable controller off line.	An alarm should be generated.	_____
	Notes: _____		
13	Simulate a data circuit going off line.	An alarm should be generated.	_____
	Notes: _____		
14	Simulate a point not responding to a command.	An alarm should be generated.	_____
	Notes: _____		
15	Simulate a change of state without command.	An alarm should be generated.	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved
DDC FOR HVAC			
16	Initiate an alarm condition such as a fan fail to start.	DDC system shall dial a pager and send a numerical alarm. DDC system shall dial an e-mail server. The node shall be able to dial and connect to a remote server and send an e-mail via Simple Mail Transfer Protocol (SMTP). DDC system shall send an e-mail over IP Network. The alarm handling node shall be capable of connecting to an IP network and sending e-mail via Simple Mail Transfer Protocol (SMTP).	_____

Notes: _____

_____

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Twelve
TITLE: Trending

OBJECTIVE:

1. To validate the capability for historical trend data collection and presentation

2. To validate the capability for real time trend data collection and presentation

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The Contractor shall provide documentation of trending capability in comparison with specification.

2. Equipment

a. Provide GPPC or ASC and workstation/server programmed with trend data.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Set up a trend with a 1 second sample rate.	It shall be possible to collect data on a 1 second sample rate.	_____
	Notes: _____		
2	Set up a trend to start and stop at specific times.	It shall be possible to start and stop a trend based on time.	_____
	Notes: _____		
3	Open a trend data display that has 8 values trended versus time.	Trend plots shall show all 8 variables as a function of time.	_____
	a) historical data	_____	_____

Item	Action Item	Expected Results	Approved
	b) instantaneous data		
	Notes:		
4	Open a pre-programmed trend data presentation.	Trend plot shall open without operator programming.	
	Notes:		
5	Open the trend configuration dialog box and set up a trend.	Operator shall be able to configure a trend plot.	
	Notes:		
6	Set up a trend for a randomly selected binary value and a randomly selected analog value.	Any binary or analog variable shall be trendable.	
	Notes:		
7	Verify that historical trend data is stored on the hard drive.	With the controller offline, historical trend data from that controller shall be presented in a graphical form.	
	Notes:		
8	Export trend log data to Microsoft Excel for manipulation and printing by the operator.	Data shall be presented in a ****.xls form.	
	Notes:		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Thirteen
TITLE: Demand Limiting

OBJECTIVE:

1. Verify M&C software has the capability of performing demand-limiting strategies

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The contractor shall provide documentation of the specific equipment being monitored.

b. The contractor shall provide documentation of the load shed priority and the equipment associated with the priorities.

2. Equipment

a. The Contractor shall provide GPPC and ASC programmed for demand-limit strategies.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	From the home page of the M&C go to or click on the graphical demand-limiting page.	The demand-limiting page will open without any errors.	_____
	Notes: _____		
2	Document the present kW load_____.	The M&C will display the actual kW.	_____
	Notes: _____		
3	Set kW limit setpoint to cause program to shed load.	_____	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved
4	Turn off 25% of the mechanical equipment being monitored.	The kW usage will decrease.	
	Notes:		
5	Allow the building(s) to remain at 75% for a given time as to generate a temperature load.	The building(s) will warm-up/cool down.	
	Notes:		
6	After time period has expired, turn all equipment on at the same time.	The kW usage will greatly increase. The M&C will stop other pieces of equipment as to shed the load. The equipment shut down will be priority based. After the building(s) come under temperature control the M&C will start all of the equipment. The equipment start up will be priority based.	
	Notes:		
7	Verify the building(s) remain under temperature control and go back to the home page.	The building(s) will come under control. The home page will be displayed.	
	Notes:		
8	Reset kW setpoint to normal limits.	The UMCS goes back to normal control.	
	Notes:		

Item	Action Item	Expected Results	Approved

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Fourteen
TITLE: Report Generation

OBJECTIVE:

1. To demonstrate that M&C software has ability to generate reports in a fixed format initialized by operator request

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The contractor shall provide documentation of all report logs set-up and the equipment associated with the report logs.

2. Equipment

a. The contractor shall provide server/workstation, GPPC, ASC and I/O to create reports.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Manually generate a report for viewing on the workstation.	Report shall present itself for viewing without disrupting the operation of the control system.	_____
	Notes: _____		
2	Manually generate a report and direct it to a specific printer.	Report shall print on the specified printer.	_____
	Notes: _____		
3	Verify that the report contains the date and time associated with the raw data.	Data samples listed in the report shall have the associated date and time the samples were collected.	_____

Item	Action Item	Expected Results	Approved
	Notes: _____		
4	Verify that the report has the date and time the report was generated.	The report shall include the date and time of the report generation.	_____
	Notes: _____		
5	Save a report to a file that is compatible with Microsoft Office products.	The report shall be saved in a ***.xls format.	_____
	Notes: _____		
6	Generate a comma delimited file with trend log data.	The comma delimited data shall be produced.	_____
	Notes: _____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Fifteen
TITLE: UPS Test

OBJECTIVE:

1. Validate UPS requirements

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. The contractor provides documentation on UPS.

2. Equipment

a. The server/workstation and the UPS needs to be on and operating for a minimum of one week.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	The UMCS home graphic page is called up.	The home page is displayed.	_____
	Notes: _____		
2	Unplug the UPS from the wall outlet.	The UMCS home page remains displayed. UPS LED-warning lights if applicable. UPS sound audible warning alarm if applicable.	_____
	Notes: _____		
3	Log out of the home page of the M&C and then log back into it.	The UPS will not affect the UMCS hardware and all associated software.	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved
4	Allow the UPS to be unplugged for 20 minutes.	The UPS will not affect the UMCS hardware and all associated software.	_____
	Notes: _____		
5	Return the UPS plug to the wall outlet.	The UPS will not affect the UMCS hardware and all associated software.	_____
	Notes: _____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Sixteen
TITLE: EIA-709.1B to IP Router Test

OBJECTIVE:

1. Validate EIA-709.1B to IP Router requirements

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Submittal information on router and O&M manual on network analysis tool.

2. Equipment

a. The router needs to be on and operating.

b. Provide a LONWORKS® network analysis tool and router configuration tool.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS			
1	Connect and open network analysis tool and verify router.	Tool shall identify function, network address, and identifier of the device.	_____
	Notes: _____		
2	Using router configuration tool, open network properties dialog box.	Router shall be utilizing a static IP address and shall not be configured for DHCP.	_____
	Notes: _____		
3	Confirm LON data is transmitted to/from LON bus to IP network.	All LONWORKS® network data is being transmitted to/from the IP network.	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Seventeen
TITLE: EIA-709.1B Router and Repeater

OBJECTIVE:

1. Validate EIA-709.1B Router and Repeater requirements

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Submittal information on router/repeater and O&M Manual on network analysis tool.

2. Equipment

a. The router needs to be on and operating for a minimum of one week.

b. The repeater needs to be on and operating for a minimum of one week.

c. Provide a LONWORKS® network analysis tool and router/repeater configuration tool.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
DDC FOR HVAC			
1	Connect and open network analysis tool and verify router and repeater.	Tool shall identify function, network address, and identifier of the devices.	_____
	Notes: _____		
2	Using router configuration tool, open the properties dialog box. Verify what data is configured to pass through router.	Only the data that is configured to pass through the router is being sent.	_____
	Notes: _____		
3	Using repeater	Dialog box opens.	

Item	Action Item	Expected Results	Approved
	configuration tool, open the properties dialog box.		_____
	Notes: _____		
	_____		
4	Verify that repeater is configured as a repeater and that all data is being sent.	Verify that all data is being sent through the repeater.	_____
	Notes: _____		
	_____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Eighteen
TITLE: EIA-709.1B Gateway Test

OBJECTIVE:

1. Validate EIA-709.1B Gateway requirements.

INITIAL REQUIREMENTS/CONDITIONS

1. Submittals

a. Contractor shall provide a list of all software that will be used to verify ANSI-709.1 Gateway configuration.

b. Provide a LonMark external interface file (XIF) for the gateway.

2. Equipment

a. The gateway needs to be on and operating.

b. Provide a LonWorks® network analysis tool and gateway configuration tool.

3. Reference Documentation

a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS and DDC FOR HVAC			
1	Connect a LONWORKS® Network Analysis Tool to the network.	a. Tool shall identify function, network address, and identifier of the device. b. All network traffic from gateway shall be utilizing the ANSI/EIA-709.1 protocol.	_____
	Notes: _____		
2	Use gateway configuration tool to verify or create a binding from gateway to a LONWORKS® controller on the network.	a. Gateway allows binding of the Standard Network Variable Types from the gateway to a LONWORKS® controller. b. Information from gateway should be bounded and	

Item	Action Item	Expected Results	Approved
		LONWORKS® controller should be receiving data.	_____
	Notes: _____		
	_____		
3	Using gateway or network configuration tool verify the following:		
	Open the properties dialog box for one of the configured SNVTs.	Gateway should allow the SNVT to be transmitted on "min", "max" and "delta".	_____
	Rename one of the SNVTs from the gateway.	Gateway should allow all variable names to be customized.	_____
	Check total capacity of Gateway.	Gateway shall have 50% extra capacity to map over additional points.	_____
	Notes: _____		
	_____		
4	Press service pin on gateway.	Gateway should broadcast the neuron ID and Program ID over the network.	_____
	Notes: _____		
	_____		
5	Remove power source from gateway for two hours. Then return power to gateway.	Gateway should retain all configuration data.	_____
	Notes: _____		
	_____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Nineteen
TITLE: Local Display Panel (LDP)

OBJECTIVE:

1. To demonstrate capability of the Local display panel to view and override control points

INITIAL REQUIREMENTS/CONDITIONS

1. Submittal

   a. O & M Manual for LDP

2. Equipment

   a. Hardware and software to connect and demo LDPconfiguration tool

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
DDC FOR HVAC			
1	Connect LDP to LON bus. Push service pin button on LDP.	LDP Controller should broadcast its neuron ID.	_____
	Notes: _____		
2	Use navigation buttons on LDP to display a status point such as a temperature or fan status.	LCP should allow user to read all status points.	_____
	Notes: _____		
3	Use navigation buttons to display a control point such as a discharge air temperature setpoint.	LCP should allow user to read all control points.	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved
4	Use LDP to override setpoint.	System accepts new setpoint. Verify system reacts to new setpoint.	_____
	Notes: _____		
5	Use LDP to release local control override.	Verify system returns to normal control.	_____
	Notes: _____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

TEST NUMBER: Twenty
TITLE: Network Configuration Tool

OBJECTIVE:

1. To validate the performance of the network configuration tool

INITIAL REQUIREMENTS/CONDITIONS

1. Submittal

   a. Network configuration tool manuals

2. Equipment

   a. Hardware, network connection, LNS database, and network configuration tool

3. Reference Documentation

   a. List user manual documentation and sections pertaining to the testing.

4. Date of Test: _____
5. Time of Test: _____
6. Contractor's Representative: _____
7. Government's Representative: _____

TEST PROCEDURES

Item	Action Item	Expected Results	Approved
UMCS AND DDC FOR HVAC			
1	Open network configuration tool and verify LNS data for project opens is being used.	The Network Configuration Tool is being used and entire LNS database for project is exposed.	_____
	Notes: _____		
2	Open a typical LNS plug-in.	Plug-in shall open and enable configuration of the device.	_____
	Notes: _____		
3	Reconstruct a database by connecting to an existing network and uploading the data.	The database and drawing shall be created.	_____
	Notes: _____		

Item	Action Item	Expected Results	Approved
4	Verify that a graphical interface is use.	Note that Network Configuration Tool uses Visio (type) as a graphical interface.	_____
	Notes: _____		
5	Print the graphical representation.	Printing shall be successful.	_____
	Notes: _____		
6	Merge two LNS databases into a single database.	The merge shall be successful.	_____
	Notes: _____		
7	Print reports from network configuration tool.	Address table, SNVT I/O table, and SCPT/UCPT table reports shall be successfully printed.	_____
	Notes: _____		
8	Randomly select a sample of network variable and confirm they are using correct SNVT types.	Correct SNVT types were used.	_____
	Notes: _____		

End of Test

Specific Abbreviations:
Y = Yes
N = No
NA = Not Applicable

-- End of Section --

SECTION 25 10 10

UTILITY MONITORING AND CONTROL SYSTEM (UMCS)
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI INCITS 154	(1988; R 2004) Office Machines and Supplies - Alphanumeric Machines-Keyboard Arrangement

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135	(2004; Int 1 thru 5 2004; Addenda A 2004; Errata 2005; Int 6 thru 15 2005; Int 16 thru 18 2006; Addenda C 2006; Addenda D 2006; Errata to Addenda D 2006; Int 19 thru 22 2007; Addenda F 2007; Addenda E 2007; Errata 2007, Errata 2008, Errata 2008; Int 23 thru 28 2008; Addenda M 2008) BACnet
ASHRAE FUN IP	(2005) Fundamentals Handbook, I-P Edition

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1B	(2002) Control Network Protocol Specification
CEA-709.3	(1999) Free-Topology Twisted-Pair Channel Specification
CEA-852-A	(2004) Tunneling Component Network Protocols Over Internet Protocol Channels

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002) IEEE Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE Std 100	(2000) The Authoritative Dictionary of IEEE Standards Terms

IEEE Std 802.1D	(2004; Amendment 2004) Media Access Control Bridges
IEEE Std 802.2	(1998; R 2003) Standards for Local Area Networks: Logical Link Control
IEEE Std 802.3	WARNING: Text in tags exceeds the maximum length of 300 characters

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO OSI Model	Open Systems Interconnection Reference Model

LONMARK INTERNATIONAL (LonMark)

LonMark SNVT List	(2002) LonMark SNVT Master List; Version 11 Revision 2
LonMark XIF Guide	(2001) LonMark External Interface File Reference Guide; Revision 4.0B

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2003) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 262	(2006) Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces
NFPA 70	(2007; AMD 1 2008) National Electrical Code - 2008 Edition

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA J-STD-607-A	(2002) Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
TIA/EIA-568-B.1	(2001 Addendums 2001, 2003, 2003, 2003, 2004, 2007) Commercial Building Telecommunications Cabling Standard - Part 1: General Requirements
TIA/EIA-606-A	(2002) Administration Standard for the Telecommunications Infrastructure

THE INTERNET ENGINEERING TASK FORCE (IETF)

RFC 1112	(1989) Host Extensions for IP Multicasting (IGMP)
RFC 1371	(1992) Choosing a "Common IGP" for the IP Internet

RFC 1812	(1995) Requirements for IP Version 4 Routers
RFC 2131	(1997) Dynamic Host Configuration Protocol
RFC 2784	(2000) Generic Routing Encapsulation (GRE)
RFC 768	(1980) User Datagram Protocol (UDP)
RFC 791	(1981) Internet Protocol (IP)
RFC 792	(1981) Internet Control Message Protocol (ICMP)
RFC 793	(1981) Transmission Control Protocol (TCP)
RFC 821	(2001) Simple Mail Transfer Protocol (SMTP)
RFC 826	(1982) Ethernet Address Resolution Protocol (ARP)

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-2202	(Rev A) Energy Monitoring and Control Systems, Factory Tests

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC EMC	(2002) FCC Electromagnetic Compliance Requirements

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 1778	(2005; Rev thru Jul 2006) Uninterruptible Power Systems
UL 60950	(2000; Rev thru Mar 2002) Safety of Information Processing and Business Equipment
UL 916	(1998; Rev thru Mar 2006) Energy Management Equipment

1.2 DEFINITIONS

The following list of definitions may contain terms not found elsewhere in this Section but are included here for completeness.

1.2.1 Application Specific Controller

A device that is furnished with a pre-established built in application that is configurable but not re-programmable. An ASC has a fixed factory-installed application program (i.e Program ID) with configurable settings.

1.2.2 Binary

A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level. 'Digital' is sometimes used interchangeably with 'binary'.

1.2.3 Binding

The act of establishing communications between CEA-709.1B devices by associating the output of a device to the input of another.

1.2.4 Building Control Network

The CEA-709.1B control network installed under Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS consisting of a backbone and one or more local control busses.

1.2.5 Building Point of Connection (BPOC)

The BPOC is the point of connection between the UMCS network backbone (an IP network) and the building control network backbone. The hardware at this location, that provides the connection is referred to as the BPOC Hardware. In general, the term "BPOC Location" means the place where this connection occurs, and "BPOC Hardware" means the device that provides the connection. Sometimes the term "BPOC" is used to mean either and its actual meaning (i.e. location or hardware) is determined by the context in which it is used.

1.2.6 Channel

A portion of the control network consisting of one or more segments connected by repeaters. Channels are separated by routers. The device quantity limitation is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 128 devices per channel.

1.2.7 Configuration Parameter

Controller setting usually written to EEPROM. Also see 'Standard Configuration Parameter Type (SCPT).

1.2.8 Control Logic Diagram

A graphical representation of control logic for multiple processes that make up a system.

1.2.9 Domain

A grouping of up to 32,385 nodes that can communicate directly with each other. (Devices in different domains cannot communicate directly with each other.) Part of the Node Addressing scheme.

1.2.10 Explicit Messaging

A method of communication between devices where each message contains a message code that identifies the type of message and the devices use these codes to determine the action to take when the message is received. These messages are non-standard and often vendor (application) dependent.

1.2.11 External Interface File (XIF)

A file which documents a device's external interface, specifically the number and types of LonMark objects; the number, types, directions, and connection attributes of network variables; and the number of message tags.

1.2.12 Functional Profile

The description of one or more LonMark Objects used to classify and certify devices.

1.2.13 Gateway

A device that translates from one protocol to another. Gateways are also called Communications Bridges or Protocol Translators.

1.2.14 General Purpose Programmable Controller (GPPC)

Unlike an ASC, a GPPC is not furnished with a fixed application program. A GPPC can be (re-)programmed, usually using vendor-supplied software.

1.2.15 LonMark Object

A collection of network variables, configuration parameters, and associated behavior defined by LonMark International and described by a Functional Profile. Defines how information is exchanged between devices on a network (inputs from and outputs to the network).

1.2.16 LNS Plug-in

Software which runs in an LNS compatible software tool. Device configuration plug-ins provide a 'user friendly' interface to configuration parameters.

1.2.17 LonMark

See LonMark International. Also, a certification issued by LonMark International to CEA-709.1B devices.

1.2.18 LonMark International

Standards committee consisting of numerous independent product developers and systems integrators dedicated to determining and maintaining the interoperability guidelines for the LonWorks industry. Maintains guidelines for the interoperability of CEA-709.1B devices and issues the LonMark Certification for CEA-709.1B devices

1.2.19 LonMark Interoperability Association

See 'LonMark International'.

1.2.20 LonWorks

The overall communications technology, developed by Echelon Corporation, for control systems. The term is often used to refer to the technology in general, and may include reference to any/all of the: protocol, network management, and interoperability guidelines where the technology is based on the CEA-709.1B protocol and employs interoperable devices along with the capability to openly manage these devices (via multiple vendors) using a

network configuration (or service) tool.

1.2.21 LonWorks Network Services (LNS)

A network management and database standard for CEA-709.1B devices.

1.2.22 Monitoring and Control (M&C) Software

The UMCS 'front end' software which performs supervisory functions such as alarm handling, scheduling and data logging and provides a user interface for monitoring the system and configuring these functions.

1.2.23 Network Variable

See 'Standard Network Variable Type (SNVT)'.

1.2.24 Network Configuration Tool

The software used to configure the control network and set device configuration properties. This software creates and modifies the control network database (LNS Database).

1.2.25 Node

A device that communicates using the CEA-709.1B protocol and is connected to an CEA-709.1B network.

1.2.26 Node Address

The logical address of a node on the network. Variations in node addressing are possible, but the 'Domain, Subnet, Node' format is the established standard for this specification.

1.2.27 Node ID

A unique 48-bit identifier assigned (at the factory) to each CEA-709.1B device. Sometimes called the Neuron ID.

1.2.28 Program ID

An identifier (number) stored in the device (usually EEPROM) that identifies the node manufacturer, functionality of device (application & sequence), transceiver used, and the intended device usage.

1.2.29 Repeater

A device that connects two control network segments and retransmits all information received on one side onto the other.

1.2.30 Router

A device that connects two channels and controls traffic between the channels by retransmitting signals received from one subnet onto the other based on the signal destination. Routers are used to subdivide a control network and to control bandwidth usage.

1.2.31 Segment

A single section of a control network that contains no repeaters or

routers. The device quantity limitation is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 64 devices per segment.

1.2.32 Service Pin

A hardware push-button on a device which causes the device to broadcast a message (over the control network) containing its Node ID and Program ID. This broadcast can also be initiated via software.

1.2.33 Standard Configuration Parameter Type (SCPT)

Pronounced 'skip-it'. A standard format type (maintained by LonMark International) for Configuration Parameters.

1.2.34 Standard Network Variable Type (SNVT)

Pronounced 'snivet'. A standard format type (maintained by LonMark International) used to define data information transmitted and received by the individual nodes. The term SNVT is used in two ways. Technically it is the acronym for Standard Network Variable Type, and is sometimes used in this manner. However, it is often used to indicate the network variable itself (i.e. it can mean "a network variable of a standard network variable type"). In general, the intended meaning should be clear from the context.

1.2.35 Subnet

Consists of a logical (not physical) grouping of up to 127 nodes, where the logical grouping is defined by node addressing. Part of the Node Addressing scheme.

1.2.36 TP/FT-10

A Free Topology Twisted Pair network defined by CEA-709.3. This is the most common media type for an ANSI-709.1 control network.

1.2.37 UMCS Network

An IP network connecting multiple building level control networks using the CEA-852-A standard.

1.2.38 User-defined Configuration Parameter Type (UCPT)

Pronounced 'u-keep-it'. A Configuration Parameter format type that is defined by the device manufacturer.

1.2.39 User-defined Network Variable Type (UNVT)

A network variable format defined by the device manufacturer. Note that UNVTs create non-standard communications (other vendor's devices may not correctly interpret it) and may close the system and therefore are not permitted by this specification.

1.3 SYSTEM DESCRIPTION

The Utility Monitoring and Control System (UMCS) shall perform supervisory control and monitoring of a base-wide as specified and shown. The system shall be compatible with the existing base-wide Energy Management & Control System(EMCS) front end located at 37th CES, Building

5595, Room 111. The building automation & control system (BACS) shall utilize intelligent distributed control modules, communicating over a controller network in accordance with ASHRAE 135. The UMCS shall interface to local building controls installed per Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS, as well as stand alone control systems. The UMCS shall maintain the LNS database(s) for the entire network.

1.3.1 System Requirements

The Contractor shall provide a UMCS in accordance with UL 916 and with the following characteristics:

a. The UMCS shall include an IP network as shown and specified and shall interface to building level control networks using CEA-709.1B TP/FT-10 to IP Routers or IP Routers as specified.

b. The system shall perform supervisory monitoring and control functions including but not limited to Scheduling, Alarm Handling, Trending, Report Generation and Electrical Peak Demand Limiting as specified.

c. The system shall include a user interface which provide a Graphical User Interface which shall allow for graphical navigation between systems, graphical representations of systems, access to real-time data for systems, ability to override points in a system, access to all supervisory monitoring and control functions.

d. All software used by the UMCS shall be licensed to and delivered to the installation as specified.

e. All necessary documentation, configuration information, configuration tools, programs, drivers, and other software shall be licensed to and otherwise remain with the Government such that the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor.

f. The Contractor shall provide sufficient documentation and data, including rights to documentation and data, such that the Government or their agents can execute work to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor.

g. All communication between the UMCS and building networks shall be via the CEA-709.1B protocol over the IP network in accordance with CEA-852-A.

1.3.2 Symbols, Definition and Abbreviations

Symbols, definitions, and engineering unit abbreviations used in information displays, submittals and reports shall be as shown in the contract drawings. Symbols, definitions and abbreviations not in the contract drawings shall conform at a minimum to IEEE Std 100 and the ASHRAE FUN IP, as applicable.

1.3.3 System Units and Accuracy

System displays, print-outs and calculations shall be performed in English

(inch-pound) units. Calculations shall have accuracy equal to or exceeding sensor accuracy as specified in Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS. Displays and printouts shall have precision and resolution equal to or exceeding sensor accuracy as specified in Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.

Technical data packages consisting of computer software and technical data (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications shall be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered 'shop drawings' under the Federal Acquisition Regulation Supplement (FARS) and shall contain no proprietary information and shall be delivered with unrestricted rights.

The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES, the CONTRACT CLAUSES and DD Form 1423 and according to the sequencing specified in paragraph PROJECT SEQUENCING:

SD-02 Shop Drawings

UMCS Contractor Design Drawings; G, DO

UMCS Contractor Design Drawings in hard copy and on CDROM in Microstation format.

Draft As-Built Drawings; G, DO

Draft As-Built Drawings in hard copy and on CDROM in Microstation format.

Final As-Built Drawings; G, DO

Final As-Built Drawings in hard copy and on CDROM in Microstation format.

SD-03 Product Data

Product Data Sheets; G, DO

Copies of all manufacturer catalog cuts and specification sheets for all products (equipment) specified in PART 2 and supplied under this contract.

Computer Software; G, DO

The most recent versions of all computer software provided under this specification delivered as a Technical Data Package. The

user manuals for all software delivered for this project shall be submitted with the software.

SD-05 Design Data

Network Bandwidth Usage Calculations; G, DO

Four copies of the Network Bandwidth Usage Calculations.

SD-06 Test Reports

Existing Conditions Report; G, DO

Four copies of the Existing Conditions Report.

Factory Test Procedures; G, DO

Four copies of the Factory Test Procedures. The Factory Test Procedures may be submitted as a Technical Data Package.

Factory Test Report; G, DO

Four copies of the Factory Test Report. The Factory Test Report may be submitted as a Technical Data Package.

Start-Up and Start-Up Testing Report; G, DO

Four copies of the Start-Up and Start-Up Testing Report. The Start-Up and Testing report may be submitted as a Technical Data Package.

PVT Phase I Procedures; G, DO

Four copies of the PVT Phase I Procedures. The PVT Procedures may be submitted as a Technical Data Package.

PVT Phase I Report; G, DO

Four copies of the PVT Phase I Report. The PVT Phase I Report may be submitted as a Technical Data Package.

PVT Phase II Report; G, DO

Four copies of the PVT Phase II Report. The PVT Phase II Report may be submitted as a Technical Data Package.

Post-Construction QC Checklist; G, DO

Four copies of the Post-Construction QC Checklist.

SD-10 Operation and Maintenance Data

Preventive Maintenance Work Plan; G, DO

Four copies of the Preventive Maintenance Work Plan. The Preventive Maintenance Work Plan may be submitted as a Technical Data Package.

Basic Operator Training Documentation; G, DO

Training manuals for Basic Operator Training delivered for each trainee on the Course Attendance List with two additional copies delivered for archival at the project site. Two copies of the Course Attendance List shall be delivered with the archival copies. The Basic Operator Training Documentation may be submitted as a Technical Data Package.

Advanced Operator Training Documentation; G, DO

One set of training manuals delivered for each trainee on the Course Attendance List with two additional copies delivered for archival at the project site. Two copies of the Course Attendance List shall be delivered with the archival copies. The Advanced Operator Training Documentation may be submitted as a Technical Data Package.

Operator Refresher Training Documentation; G, DO

One set of training manuals delivered for each trainee on the Course Attendance List with two additional copies delivered for archival at the project site. Two copies of the Course Attendance List shall be delivered with the archival copies. The Operator Refresher Training Documentation may be submitted as a Technical Data Package.

Operation and Maintenance (O&M) Instructions; G, DO

Four bound O&M Instructions and two copies of the Instructions in PDF format on CD-ROM. Bound Instructions shall be indexed and tabbed. Instructions in PDF form shall be a single PDF file, or multiple PDF files with a PDF file table of contents containing links to the other files. O&M Instructions may be submitted as a Technical Data Package.

SD-11 Closeout Submittals

Closeout QC Checklist; G, DO

Four copies of the Closeout QC Checklist.

1.5 PROJECT SEQUENCING

TABLE I: PROJECT SEQUENCING specifies the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3: EXECUTION (denoted by an 'E' in the 'TYPE' column).

a. Sequencing for submittals: The sequencing specified for submittals is the deadline by which the submittal must be initially submitted to the Government. Following submission there will be a Government review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Government, the Contractor shall revise the submittal and resubmit it to the Government within 14 days of notification that the submittal has been rejected. Upon re-submittal there shall be an additional Government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.

b. Sequencing for Activities: The sequencing specified for activities indicates the earliest the activity may begin.

c. Abbreviations: In TABLE I the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

TABLE I. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
1	S	Factory Test Procedures	
2		Perform Factory Test	AAO #1
3	S	Factory Test Report	14 days ACO #2
4	S	Existing Conditions Report	30 days AAO #3
5	S	Design Drawings	45 days AAO #3
6	S	Product Data Sheets	45 days AAO #3
7	S	Network Bandwidth Calculations	45 days AAO #3
8	S	Pre-construction QC Checklist	45 days AAO #3
9	E	Install UMCS	AAO #4 thru #8
10	E	Start-Up and Start-Up Testing	ACO #9
11	S	Post-Construction QC Checklist	14 days ACO #10
12	S	Computer Software	14 days ACO #10
13	S	Start-Up and Start-Up Testing Report	14 days ACO #10
14	S	Draft As-Built Drawings	21 days ACO #10
15	S	PVT Phase I Procedures	14 days before sched. start of #16 and AAO #13
16	E	PVT Phase I	AAO #15 and #14
17	S	PVT Phase I Report	14 days ACO #16
18	S	Preventive Maintenance Work Plan	AAO #13
19	S	O&M Instructions	AAO #13
20	S	Basic Operator Training Documentation	AAO #13 and 17 days before scheduled start of #21
21	E	Basic Operator Training (PVT Phase II)	AAO #18, #19 and #20
22	S	PVT Phase II Report	14 days ACO #21
23	S	Final As-Built Drawings	30 days AAO #22
24	S	Advanced Operator Training Documentation	7 days before sched. start of #25 and AAO #20
25	E	Advanced Operator Training	ACO #21, 14 days AAO #24, and no later than 60 days ACO #21
26	S	Operator Refresher Training Documentation	7 days before #27 and AAO #20 and #24
27	E	Operator Refresher Training	between 45 and 60 days ACO #21 and AAO #26
28	S	Closeout QC Checklist	ACO #25

1.6 QUALITY CONTROL (QC) CHECKLISTS

The Contractor's Chief Quality Control (QC) Representative shall complete the QC Checklist in APPENDIX A and submit a Pre-Construction QC Checklist,

Post-Construction QC Checklist and a Closeout QC Checklist as specified. The QC Representative shall verify each item in the Checklist and initial in the provided area to indicate that the requirement has been met. The QC Representative shall sign and date the Checklist prior to submission to the Government.

1.7 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

The UMCS Operation and Maintenance Instructions shall include:

a. Procedures for the UMCS system start-up, operation and shut-down.

b. Final As-Built drawings.

c. Routine maintenance checklist. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all installed devices, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.

d. Qualified service organization list.

e. Start-Up and Start-Up Testing Report.

f. Performance Verification Test (PVT) Procedures and Reports.

1.8 MAINTENANCE AND SERVICE

The Contractor shall perform inspection, testing, cleaning, and part or component replacement as specified and as required to maintain the warranty. Work includes providing necessary preventive and unscheduled maintenance and repairs to keep the UMCS operating as specified, and accepted by the Government, and other services as specified. Work shall comply with manufacturer's recommendations and industry standards. The Contractor shall provide technical support via telephone during Contractor's regular working hours.

1.8.1 Work Coordination

The Contractor shall schedule and arrange work to cause the least interference with the normal Government business and mission. In those cases where some interference may be essentially unavoidable, the Contractor shall coordinate with the Government to minimize the impact of the interference, inconvenience, equipment downtime, interrupted service and personnel discomfort.

1.8.2 Work Control

When the Contractor completes work on a system or piece of equipment, that system or piece of equipment shall be free of missing components or defects which would prevent it from functioning as originally intended and designed. Replacements shall conform to the same specifications as the original equipment. During and at completion of work, debris shall not be allowed to spread unnecessarily into adjacent areas nor accumulate in the work area itself.

1.8.3 Working Hours

Working hours are from 7:30 A.M. to 4:00 P.M. local time Mondays through Fridays except Federal holidays.

1.8.4 Equipment Repairs

Equipment repairs shall be initiated and completed within the following time periods. Time periods shall be measured as actual elapsed time from first notification, including working and non-working hours:

a) for non-redundant computer server hardware, initiate within 4 hours and complete within 8 hours.

b) for non-redundant computer workstation hardware, initiate within 4 hours and complete within 8 hours.

c) for redundant computer server hardware, initiate within 36 hours and complete within 5 days.

d) for redundant computer workstation hardware, initiate within 2 days and complete within 5 days.

e) for active (powered) network hardware, initiate within 4 hours and complete within 6 hours.

f) for cabling and other passive network hardware, initiate within 16 hours and complete within 5 days.

Repair is the restoration of a piece of equipment, a system, or a facility to such condition that it may be effectively used for its designated purposes. Repair may be overhaul, reprocessing, or replacement of nonfunctional parts or materials or replacement of the entire unit or system.

1.8.5 Replacement, Modernization, Renovation

The Government may replace, renovate, or install new equipment at Government expense and by means not associated with this contract. Replaced, improved, updated, modernized, or renovated systems and equipment interfaced to the system may be added to the Contractor's maintenance and service effort as a modification.

1.8.6 Access To UMCS Equipment

Access by the Contractor shall be in accordance with the following:

a. The Contractor shall be responsible for coordinating access to facilities and arranging that they be opened and closed during and after the accomplishment of the work effort. For Contractor access to a controlled facility the Contractor shall contact the Government for assistance.

b. The Government may provide keys for access to UMCS equipment where the Government determines such key issuance is appropriate. The Contractor shall establish and implement methods of ensuring that keys issued to the Contractor by the Government are not lost or misplaced, are not used by unauthorized persons, and are not duplicated.

1.8.7 Records, Logs, and Progress Reports

The Contractor shall keep records and logs of each task, and shall organize cumulative chronological records for each major component, and for the complete system. A continuous log shall be maintained for the UMCS. Complete logs shall be kept and shall be available for inspection on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the UMCS.

1.8.8 Preventive Maintenance Requirements

The Contractor shall perform maintenance procedures as described below, or more often if required by the equipment manufacturer.

1.8.8.1 Preventive Maintenance Work Plan

The Contractor shall prepare a Preventive Maintenance Work Plan to schedule all required preventive maintenance. Government approval of the Work Plan shall be obtained as specified in paragraph PROJECT SEQUENCING. The Contractor shall strictly adhere to the approved work plan to facilitate Government verification of work. If the Contractor finds it necessary to reschedule maintenance, a written request shall be made to the Government detailing the reasons for the proposed change at least five days prior to the originally scheduled date. Scheduled dates shall be changed only with the prior written approval of the Government.

1.8.8.2 Semiannual Maintenance

Contractor shall perform the following Semiannual Maintenance as specified:

a. Perform data backups on all Server Hardware.

b. Run system diagnostics and correct diagnosed problems.

c. Perform fan checks and filter changes for UMCS hardware.

d. Perform all necessary adjustments on printers.

e. Resolve all outstanding problems.

f. Install new ribbons, ink cartridges and toner cartridges into printers, and ensure that there is at least one spare ribbon or cartridge located at each printer.

1.8.8.3 Maintenance Procedures

a. Maintenance Coordination: Any scheduled maintenance event that may result in component downtime shall be coordinated with the Government as follows. Time periods shall be measured as actual elapsed time from beginning of equipment off-line period, including working and non-working hours.

(1) For non-redundant computer server hardware, provide 14 days notice, components shall be off-line for no more than 8 hours.

(2) For non-redundant computer workstation hardware, provide 7 days notice, components shall be off-line for no more than 8 hours.

(3) for redundant computer server hardware, provide 7 days notice,

components shall be off-line for no more than 36 hours.

(4) For redundant computer workstation hardware, provide 4 days notice, components shall be off-line for no more than 48 hours.

(5) For active (powered) network hardware, provide 14 days notice, components shall be off-line for no more than 6 hours.

(6) For cabling and other passive network hardware, provide 21 days notice, components shall be off-line for no more than 12 hours.

b. Software/Firmware: Software/firmware maintenance shall include operating systems, application programs, and files required for the proper operation of the UMCS regardless of storage medium. User (project site) developed software is not covered by this contract, except that the UMCS software/firmware shall be maintained to allow user creation, modification, deletion, and proper execution of such user-developed software as specified. The Contractor shall perform diagnostics and corrective reprogramming as required to maintain total UMCS operations as specified. The Contractor shall back up software before performing any computer hardware and software maintenance. The Contractor shall not modify any parameters without approval from the Government. Any approved changes and additions shall be properly documented, and the appropriate manuals shall be updated.

c. Network: Network maintenance shall include testing transmission media and equipment to verify signal levels, system data rates, errors and overall system performance.

1.8.9 Service Call Reception

a. A Government representative will advise the Contractor by phone or in person of all maintenance and service requests, as well as the classification of each based on the definitions specified. A description of the problem or requested work, date and time notified, location, classification, and other appropriate information will be placed on a Service Call Work Authorization Form by the Government.

b. The Contractor shall have procedures for receiving and responding to service calls 24 hours per day, seven days a week, including weekends and holidays. A single telephone number shall be provided by the Contractor for receipt of service calls during regular working hours. Service calls shall be considered received by the Contractor at the time and date the telephone call is placed by the authorized Government representative.

c. The Contractor shall separately record each service call request, as received on the Service Call Work Authorization form and shall complete the Service Call Work Authorization form for each service call. The completed form shall include the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion.

d. The Contractor shall respond to each service call request within

two working hours. The status of any item of work must be provided within four hours of the inquiry during regular working hours, and within 16 hours after regular working hours or as needed to meet the Equipment Repair requirements as specified.

1.8.10 Service Call Work Warranty

The Contractor shall provide a 1 year unconditional warranty on service call work. The warranty shall include labor and material necessary to restore the equipment involved in the initial service call to a fully operable condition. In the event that Contractor service call work causes damage to additional equipment, the Contractor shall be liable for labor and material to restore the system to full operation. Contractor response to service call warranty work shall be the same as required by the initial service call.

1.8.11 System Modifications

The Contractor shall make recommendations for system modification in writing to the Government. No system modifications shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the Operations and Maintenance Instructions, and other documentation affected. The Contractor shall make available to the Government software updates for all software furnished under this specification during the life of this contract. There shall be at least one scheduled update near the end of the contract period, at which time the Contractor shall make available the latest released version of all software provided under this specification, and shall install and validate it upon approval by the Government.

1.9 UMCS IP NETWORK

The IP UMCS network shall provide speeds of at least 100 Mbps on the entire network using the IP protocol. The Bit Error Rate (BER) of the data communications components shall be no greater than one error in 10E9 for the entire network. The UMCS Network shall support CEA-709.1B communications in accordance with CEA-852-A and all other necessary UMCS functionality. The Network shall use the following protocols for layers 1 through 7 as defined in the ISO OSI Model:

a. OSI Layer 1. The physical layer shall be in conformance with IEEE Std 802.3 (Ethernet) and operate at at least 100 megabits per second Mbps (100Base-T and 100Base-FX). Higher speed protocols may be used. If higher speed physical layers are used, bridging hardware shall be provided to ensure compatibility with 100 Mbps devices.

b. OSI Layer 2. The data-link layer shall be the IEEE Std 802.2 Logical Link Control (LLC), Type 1, Class 1, in combination with the IEEE Std 802.3 Protocol.

c. OSI Layer 3. The network layer shall be the Internet Protocol (IP; RFC 791), the Internet Control Message Protocol (ICMP; RFC 792), and the Address Resolution Protocol (ARP; RFC 826).

d. Layers 4 - 7. Network shall support all layer 4 protocols supported by IP (RFC 791) including but not limited to ICMP (RFC 792), IGMP (RFC 1112), TCP (RFC 793), UDP (RFC 768), IGP (RFC 1371, GRE (RFC 2784) and protocols required by CEA-852-A.

PART 2 PRODUCTS

2.1 EQUIPMENT REQUIREMENTS

2.1.1 Product Certifications

Computing devices, as defined in 47 CFR 15, supplied as part of the UMCS shall be certified to comply with the requirements of Class B computing devices.

2.1.2 Product Sourcing

Contractor supplied units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and the model and serial number in a conspicuous place. Materials and equipment shall be new standard unmodified products of a manufacturer regularly engaged in the manufacturing of such products.

2.1.3 General Requirements

The Contractor shall provide components which meet the following requirements:

a. Portions of the data communications equipment system installed in unconditioned spaces shall operate properly in an environment with ambient temperatures between +20 and 150 degrees F and ambient relative humidity between 20% and 95% noncondensing.

b. Components shall accept 100 to 125 volts AC (Vac), 60 Hz, single phase, three wire with a three-pronged, dedicated circuit outlet or be provided with a transformer to meet the component's power requirements.

c. The equipment shall meet the requirements of NFPA 70, UL 60950, NFPA 262, FCC EMC, and 47 CFR 15.

2.1.4 Product Data Sheets

For each product specified in this contract, manufacturer catalog cuts and sheets which indicate conformance to product requirements shall be submitted as specified.

2.2 NETWORK HARDWARE

2.2.1 Nameplates

Laminated plastic nameplates shall be provided for all network hardware. Each nameplate shall identify the function, network address and identifier of the device. Laminated plastic shall be 0.125 inch thick, white with black center core. Nameplates shall be a minimum of 1 by 3 inch with minimum 0.25 inch high engraved block lettering. Nameplates shall be attached to the device in conspicuous location.

2.2.2 Building Point of Connection (BPOC) Hardware

2.2.2.1 CEA-709.1B TP/FT-10 to IP Router

CEA-709.1B TP/FT-10 to IP Routers shall perform layer 3 routing of CEA-709.1B packets over an IP network in accordance with CEA-852-A. The router shall provide the appropriate connection to the IP network and

connections to the CEA-709.3 TP/FT-10 network. CEA-709.1B TP/FT-10 to IP Routers shall support the Dynamic Host Configuration Protocol (DHCP; RFC 2131 for IP configuration the use of an CEA-852-A Configuration Server (for CEA-852-A configuration), but shall not rely on these services for configuration. CEA-709.1B TP/FT-10 to IP Routers shall be capable of manual configuration.

2.2.2.2 CEA-709.1B Gateway

Gateways shall have the appropriate connection on the building-side (non-CEA-709.1B side) to interface to the building DDC system, and shall meet the following requirements:

a. It shall be capable of being installed, configured and programmed for the designated application and through the use of instructions in the manual supplied by the Contractor.

b. All software required for gateway configuration shall be provided.

c. It shall provide bi-directional protocol translation between the building level control protocol and CEA-709.1B.

d. It shall allow bi-directional mapping between Standard Network Variable Types (SNVTs) according to the LonMark SNVT List on the CEA-709.1B side and points on the building control network.

d. It shall communicate on the CEA-709.1B over an IP network in accordance with CEA-852-A. Contractor may provide a CEA-709.1B TP/FT-10 to IP Router co-located with the protocol translator to meet this requirement.

e. It shall allow binding of its standard network variables (SNVTs).

f. For the CEA-709.1B network, it shall be capable of transmitting data using the "min, max, and delta" (throttling and heartbeat) methodology.

g. It shall provide the ability to label SNVTs that are mapped to or from third party devices.

h. It shall provide capacity for mapping all required points as shown plus an additional 50% from the legacy side as SNVTs on the CEA-709.1B side and vice-versa.

i. It shall be capable of supporting polled and synchronous modifiers for network variables.

j. It shall supply a LonMark external interface file (XIF) as defined in the LonMark XIF Guide for use with LNS tools and utilities.

k. It shall have a "service pin" which, when pressed, will cause the Gateway to broadcast its 48-bit NodeID and ProgramID over the network.

l. It shall provide a configurable self-documenting string.

m. It shall retain its configuration after a power loss of an indefinite time, and shall automatically return to its pre-power loss state once power is restored.

2.2.3 IP Network Hardware

2.2.3.1 Wire and Cables

a. Interior LAN Copper Cable: Interior Copper LAN cable shall meet or exceed all requirements of Category 5 cable as specified in TIA/EIA-568-B.1. Terminations, patch panels, and other hardware shall meet or exceed Category 5 specifications and shall be as specified in SECTION 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. Cabling products shall be tested and certified for use at data speeds up to at least 100 Mbps. Other types of media commonly used within IEEE Std 802.3 LANs (e.g., 10Base-T and 10Base-2) shall be used only in cases to interconnect with existing media. Short lengths of media and transceivers may be used in these applications. The Contractor shall provide separately orderable media, taps and connectors.

b. Interior Fiber Optic Cable: Interior Fiber Optic Cable shall be Multimode or Singlemode fiber, 62.5/125 micron for multimode or 10/125 micron for singlemode with SC or ST connectors as specified in TIA/EIA-568-B.1. Terminations, patch panels, and other hardware shall be compatible with the specified fiber and shall be as specified in SECTION 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. The data communications equipment shall use the 850-nm range of multimode or 1310-nm range of singlemode fiber-optic cable. Fiber-optic cable shall be suitable for use with the 100Base-FX standard as defined in IEEE Std 802.3.

c. Exterior Fiber Optic Cable: Exterior Fiber Optic Cable shall be Multimode or Singlemode Fiber, 62.5/125 micron for multimode or 10/125 micron for singlemode micron with SC or ST connectors as specified in TIA/EIA-568-B.1. The data communications equipment shall use the 850-nm range of multimode or 1310-nm range of singlemode fiber-optic cable. Fiber-optic cable shall be suitable for use with the 100Base-FX standard as defined in IEEE Std 802.3.

2.2.3.2 Fiber Optic Patch Panel.

Fiber Optic Patch Panels shall be wall or rack mountable and designed to provide termination facilities for up to 24 fibers. Unit shall also have capability to be equipped with spliced trays, six packs (for adapters), and blank panels for easy termination of the fiber bundles and tube cables. Fiber-optic terminating equipment shall provide for mounting of ST or SC connectors on an optical patch panel. Fiber-cable management and cable-routing hardware shall be provided by the Contractor to assure conformance to minimum fiber and cable bend radii. Connectors on the patch panel shall be ST or SC feed through. Access to both sides of the panel shall be provided by the Contractor. The patch panel for the connectors shall be mounted to facilitate rearrangement and identification. Each apparatus shall have cabling and connection instructions associated with it.

2.2.3.3 Fiber Optic Media Converter

Fiber Optic media converter shall provide media conversion between layer 1 copper and fiber media to support data rates equal to the greater of the physical layer or 100 Mbps as specified in IEEE Std 802.3.

2.2.3.4 Ethernet Switch

Switches shall be IEEE Std 802.3 bridges which shall function as the center

of a distributed-star architecture and shall be "learning" bridges with spanning tree algorithms per IEEE Std 802.1D. The switch shall support the connected media types and shall have a minimum of 150% the required ports and no fewer than 4 ports. One port shall be switch selectable as an uplink port.

2.2.3.5 IP Router

The Contractor shall provide IP router network equipment. The routers shall be fully configurable for protocol types, security, and routing selection of sub-networks. The router shall meet all requirements of RFC 1812.

2.3 COMPUTER HARDWARE

2.3.1 Nameplates

Laminated plastic nameplates shall be provided for each server and workstation. Each nameplate shall identify the function, network address and identifier of the server or workstation. Laminated plastic shall be 0.125 inch thick, white with black center core. Nameplates shall be a minimum of 1 by 3 inches with minimum 0.25 inch high engraved block lettering. All nameplates shall be attached to the device in conspicuous location.

2.3.2 Server Hardware

Computer Server Hardware (server) shall be a standard unmodified digital computer of modular design currently being manufactured. The modular components of the server shall be products of a single manufacturer which advertises service in all 48 contiguous states. Server hardware shall meet the following minimum requirements.

a. Processor speed: Minimum 250% of the stated requirements of the software to be installed on the server.

b. Random Access Memory (RAM): Minimum 250% of the stated requirements of the software to be installed on the server.

c. Communications ports: One serial port, one enhanced parallel port and one USB port in addition to any ports required for the keyboard and mouse.

d. Hard Drives and Controller: Controller and Drives shall provide at least 120GB usable disk space with an average seek time of 7 milliseconds or less using hardware RAID (Redundant Array of Inexpensive Disks) at levels 1 or 5 (RAID-1 or RAID-5).

e. CD/DVD-RW Drive: Combo CD-RW with 32x read, 24x write and 16x rewrite and DVD-RW with 12x read; 4x re-write; 2x write.

f. Floppy Disk Drive and controller: High density (1.44MB) disk drive 3.5 inch diameter size.

g. Video output card: Support at least 16 bit color at a minimum resolution of 1280 by 1024 at a minimum refresh rate of 70 Hz.

h. Network Interface Card (NIC): Integrated 100Base-T Ethernet NIC with an RJ45 connector or 100Base-FX Ethernet NIC with an SC connector.

i. Monitor: Sized as shown but no less than 17 inches with a minimum resolution of 1024 by 768 pixels, non-interlaced, a maximum dot pitch of 0.28 millimeters, and a minimum refresh rate of 70Hz.

j. Keyboard: 101 key keyboard having a minimum 64 character standard ASCII character set based on ANSI INCITS 154.

k. Mouse: 2-button mouse with a minimum resolution of 400 dots per inch.

l. Hot-swappable redundant power supplies.

2.3.3 Workstation Hardware (Desktop and Laptop)

Computer Workstation Hardware (workstation) shall be a standard unmodified digital desktop computer of modular design or a laptop as shown. The modular components of the desktop, or the laptop, shall be products of a single manufacturer which advertises service in all 48 contiguous states. Workstations shall meet the following minimum requirements.

a. Processor speed: 150% the stated requirements of the software to be installed on the workstation.

b. Random Access Memory (RAM): 150% the stated requirements of the software to be installed on the workstation.

c. Communications ports:

(1) Desktop: One serial port, one enhanced parallel port and two USB ports in addition to any ports required for the keyboard and mouse.

(2) Laptop: One serial port, one enhanced parallel port, one USB port, one PCMCIA card slot, and one additional USB or PS/2 port for a mouse.

d. Hard Drive and controller:

(1) Desktop: 60GB formatted disk space with an average seek time of 7 milliseconds or less.

(2) Laptop: 40GB formatted disk space with an average seek time of 10 milliseconds or less.

e. CD-RW Drive: 24x read; 12x re-write; 24x write. For laptops the CD-RW drive shall be a fixed, modular-bay or external drive.

f. Floppy Disk Drive and controller: High density (1.44MB) disk drive 90mm (3.5inch) diameter size. For laptop workstations the floppy disk drive shall be a fixed, modular-bay or external drive.

g. Video output card:

(1) Desktop: Support at least 32 bit color at a minimum resolution of 1280 by 1024 at a minimum refresh rate of 70 Hz.

(2) Laptop: Support at least 16 bit color at a minimum resolution of 1024 by 768 at a minimum refresh rate of 60 Hz.

h. Network Interface Card (NIC):

(1) Desktop: Integrated 100Base-TX Ethernet NIC with an RJ45 connector or 100Base-FX Ethernet NIC with an SC connector.

(2) Laptop: Integrated or PCMCIA 100Base-TX Ethernet NIC with an RJ45 connector.

i. Monitor:

(1) Desktop: Monitor sized as shown but no less than 19 inches with a maximum supported resolution of no less of 1280 by 1024 pixels, non-interlaced, and a maximum dot pitch of 0.28 millimeters.

(2) Laptop: LCD Screen sized as shown but no less than 12 inches with a maximum supported resolution of no less than 1024 by 768 pixels

j. Keyboard:

(1) Desktop: 101 key keyboard having a minimum 64 character standard ASCII character set based on ANSI INCITS 154.

(2) Laptop: Standard laptop keyboard.

k. Mouse:

(1) Desktop: 2-button mouse with a minimum resolution of 400 dots per inch.

(2) Laptop: Integrated touch-pad.

2.3.4 Printers

Printers shall be local or network printers as shown. Local printers shall have a parallel or USB interface. Network printers shall have a 100Base-T interface with an RJ45 connection and shall have a firmware print spooler compatible with the Operating System print spooler.

2.3.4.1 Alarm Printer

The dot matrix alarm printers shall have a minimum 96 character standard ASCII character set based on ANSI INCITS 154 and with graphics capability. The printers shall have adjustable sprockets for paper width up to 11 inches, print at least 80 columns per line and have a minimum speed of 200 characters per second. Character spacing shall be selectable at 10, 12 or 17 characters per inch. The printers shall use sprocket-fed fanfold paper. The units shall have programmable control of top-of-form. Printers shall include floor stands with paper racks.

2.3.4.2 Laser Printer

Laser printers shall meet the following minimum requirements:

a. Resolution: 600 by 600 dots per inch.

b. Printing Time: 10 pages per minute.

c. Data Buffer Size: 10 Megabytes.

d. Media Size: 8.5 by 11 inches as shown.

e. Paper Cassette: 250 sheet capacity.

2.3.4.3 Color Printer

The color printer shall use ink jet technology, shall be a full-color printer, and shall meet the following minimum requirements:

a. Resolution: 600 by 600 dots per inch.

b. Printing Time: 2 pages per minute.

c. Data Buffer Size: 16 Megabytes.

d. Colors: Printer shall have a separate replaceable black ink cartridge or print head.

e. Media Type: Paper and transparency film.

f. Media Size: 8.5 by 11 inches and as shown.

g. Paper Cassette: 250 sheet capacity.

2.4 COMPUTER SOFTWARE

2.4.1 Operating System (OS)

The operating system (OS) shall fully support all installed software and peripherals and shall be able to obtain screen capture of the monitor display being viewed.

2.4.2 Office Automation Software

Office Automation Software shall consist of the e-mail, spreadsheet and word processing portions of the project site's standard office automation software.

2.4.3 Virus Protection Software

Virus Protection Software shall consist of the project site's standard virus protection software complete with a virus definition update subscription.

2.4.4 CEA-852-A Configuration Server

The CEA-852-A configuration server shall meet the requirements of CEA-852-A.

2.4.5 CEA-709.1B Network Configuration Tool

The network configuration tool shall meet the following minimum requirements:

a. It shall solely use LonWorks Network Services (LNS) for all network configuration and management of CEA-709.1B devices.

b. It shall be capable of executing LNS plug-ins.

c. It shall be capable of performing network database reconstruction of an CEA-709.1B control network, such that if connected to an existing CEA-709.1B network it has the ability to query the network and create an LNS database for that network and an associated network drawing.

d. It shall allow configuration of the network while off-line such that an operator may set up changes to the network while disconnected from the network, and then execute all of them once connected.

e. It shall have a graphics-based user interface, and be able to display and print a graphical representation of the control network.

f. It shall be capable of generating and printing the following reports:

(1) Table containing domain/subnet/node address and node identifier for the entire network or any subset thereof, selected by the user.

(2) Table containing Standard Network Variable (SNVT) input and output details for any CEA-709.1B device on the network.

(3) Table containing Standard and User-Defined Configuration Properties (SCPTs and UCPTs) for any CEA-709.1B device on the network.

g. It shall be capable of merging two existing standard LNS databases into a single standard LNS database.

2.4.6 Monitoring and Control (M&C) Software

The monitoring and control (M&C) software shall be an LNS-compatible client-server software package. The software shall accommodate 5000 points and shall be expandable via licensing upgrade to accommodate up to 50,000 points without requiring additional software installation. The server software shall support clients as specified and shown and shall be expandable via licensing upgrade to support no less than 50 total clients and no less than 20 clients simultaneously without requiring additional server software installation.

2.4.6.1 Passwords

The M&C software shall provide user-based access to M&C functionality. The M&C Software shall obtain user information from the OS or manage M&C user information and shall recognize at least 100 separate users and have at least 4 levels of user permissions. User permission levels (from most restrictive to most permissive) shall include:

a. Permission Level 1: View System Graphic Displays.

b. Permission Level 2: Permission Level 1 plus acknowledge alarms and set up (configure) trends and reports.

c. Permission Level 3: Permission Level 2 plus override SNVTs and set up (configure) alarms, schedules and demand limiting.

d. Permission Level 4: Permission Level 3 plus create and modify

System Graphic Displays and create custom programs.

Passwords shall not be displayed. The system shall maintain a disk file logging all activity of the system. If the file format is not plain ASCII text, the Contractor shall provide a means to export or convert the file to plain ASCII text. This file shall maintain, as a minimum, a record of all operators logged onto the system, alarm acknowledgments, commands issued and all database modifications. Passwords shall not be logged. The activity log shall be maintained at the server hardware. The system shall automatically provide a mechanism for archiving the log files for long term record storage.

2.4.6.2 Protocol Drivers

The M&C Software may include drivers to other (non-CEA-709.1B) protocols. The protocol driver shall allow all M&C Software functions to write values to and read values from points on the legacy system. The M&C software shall support reading points from the legacy system and writing these values to SNVTs on the CEA-709.1B network, and reading SNVTs from the CEA-709.1B network and writing these values to points on the legacy network. Use of the driver to integrate additional legacy systems shall not require programming but may require configuration.

2.4.6.3 System Graphic Displays

The monitoring and control (M&C) software shall include graphical displays through which an operator can perform real-time access and manipulation of the M&C functions as specified and shown. The graphical displays shall consist of building-level system (air handler units, VAV boxes, chillers, boilers etc) graphic displays, alarm displays, scheduling displays, trending displays, and demand limiting displays. Data associated with an active display shall be updated at least once every 5 seconds.

a. Navigation Scheme: System graphic displays of building-level systems and points shall be hierarchical displays using a building-to-equipment point-and-click navigation scheme. Each display shall show the building name and number. Each display shall show system wide data such as outside air temperature and humidity in the case of an HVAC system application.

(1) Each Building or Building Sub-Area display shall show the building foot print and basic floor plan, and shall clearly show and distinguish between the individual zones and the equipment serving each zone and space. The building display shall also show all space sensor and status readings, as applicable, for the individual zones such as space temperature, humidity, occupancy status, etc. The building display shall show the locations of individual pieces of monitored and controlled equipment.

(2) Each equipment display shall show a 3-dimensional representation of the individual pieces of equipment using the symbols and M&C point data types as specified. Different colors and textures shall be used to indicate various components and real time data. Color and texture meanings shall be consistent across all displays.

(3) Each display shall clearly distinguish between the following point data types and information:

(a) Real-time data.

(b) User-entered data.

(c) Overridden or operator-disabled points.

(d) Devices in alarm (unacknowledged).

(e) Out-of-range, bad, or missing data.

b. Navigation Commands: The system graphic displays shall support English language operator commands via point-and-click mouse or keyboard entry for defining and selecting points, parameters, graphics, report generation, and all other functions associated with operation. The operator commands shall be usable from any operator workstation with individual operator passwords as specified.

(1) Command Input: Operator's commands shall be full words and acronyms selected to allow operators to use the system without extensive training or any data processing backgrounds. The system shall prompt the operator in full words and acronyms for all required information, identifying acceptable command formats. The operator's response shall be a point-and-click selection, word, phrase, or acronym including parameters where required.

(2) Command Input Errors: The system shall supervise operator inputs to ensure they are correct for proper execution. Operator input assistance shall be provided whenever a command cannot be executed because of operator input errors. The system shall explain to the operator why the command cannot be executed. Conditions for which operator error assist messages shall be generated include:

(a) The command used is incorrect or incomplete.

(b) The operator is restricted from using that command.

(c) The command addresses an out-of-range or bad data point.

(d) The command addresses a point that does not exist.

(e) The command would violate constraints.

(3) Special Functions: The system shall provide the following point-and-click mouse functions, in addition to all other commands specified:

(a) HELP: shall produce an indexed or menu-driven display of all commands available to the operator. The HELP command, followed by a specific command shall produce a context sensitive listing with a short explanation of the purpose, use, and system reaction to that command.

(b) DISPLAY DIAGRAM: shall display diagrams of specific utility systems or other systems as specified.

(c) DIAGRAM DEVELOPMENT: shall allow the user to develop diagrams of specific utility systems or other systems as specified.

(d) PRINT REPORT: Shall allow the operator to initiate printing of reports.`

(4) Operator's Commands: The operator's commands shall provide the means for entry of control and monitoring commands, and for retrieval of information. Processing of operator commands shall commence within 1 second of entry, with some form of acknowledgment provided at that time. The operator's commands shall perform tasks, including:

(a) Request a display of any SNVT or calculated point or any group of related SNVTs and calculated points

(b) Startup and shutdown selected systems or devices.

(c) Override any SNVT point to an operator selected value.

(d) Release the override of a SNVT.

(e) Modify time and event scheduling.

(f) Initiate reports.

(g) Generate and format reports.

(5) System Graphic Display Hierarchy: The system graphic display shall have a hierarchical structure with at least five levels:

(a) Unit: The unit that a point is associated with, such as an AHU.

(b) Building Sub-Area: A part of a building.

(c) Building: The building that a point is located in or near.

(d) Building Group: A group of buildings.

(e) Facility: Installation included in the UMCS.

c. Display Editor: The display editor shall enable the user to create, modify, and delete displays and graphic symbols. The primary use shall be for adding and modifying one-line diagrams, status displays, system summaries, and system directories, as new controllers, points, data, and other necessary changes are made. The basic functions shall include:

(1) Create and save displays and graphic symbols.

(2) Group and ungroup graphic symbols. The grouped symbol shall be manipulated as a single symbol.

(3) Modify a portion of a graphic symbol.

(4) Save graphic symbols as a library object.

(5) Rotate and mirror a graphic symbol.

(6) Delete a graphic symbol.

(7) Place a graphic symbol on a display.

(8) Cancel the display of a graphic symbol.

(9) Assign conditions which automatically initiate the display.

(10) Overlay alphanumerics and graphics.

(11) Save new, modified, or existing graphics as new graphics.

(12) Integrate real-time data with the display.

(13) Define the background color.

(14) Define the foreground color.

(15) Locate the symbols.

(16) Position and edit alphanumeric descriptors.

(17) Establish connecting lines.

(18) Establish sources of latest data and location of readouts.

(19) Display analog values as specified.

(20) Cursor control (up, down, right, left).

(21) Create and display alphanumeric displays.

(22) Assign graphics a depth such that when there are coincident graphics the one with the lower depth is displayed.

(23) Modify graphic properties based on SNVT values, calculated values or values obtained from a legacy system.

(24) Creating conditional displays such that different graphic symbols or text are displayed based on SNVT values, calculated values or values obtained from a legacy system.

(25) Symbols Library: The library of callable display symbols shall include: Pump, Motor, Two- and Three-way Valves, Flow Sensing Element, Point and Averaging Temperature Sensors, Pressure Sensor, Humidity Sensor, Single and Double Deck Air Handling Unit, Fan, Chiller, Boiler, Air Compressor, Chilled Water Piping, Steam Piping, Hot Water Piping, Ductwork, Unit Heater, Pressure Reducing Valve, Damper, Electric Meter, Limit Switch, Flow Switch, High- and Low- Point and Averaging Temperature Switches, High- and Low-Pressure Switches, Coil, Solenoid Valve, Filter, Condensing Unit, Cooling Tower, Variable Frequency Drive (VFD), Heat Exchanger, Current Sensing Relays. Symbols shall at a minimum conform to ASHRAE FUN IP where applicable.

2.4.6.4 Scheduling

The M&C software shall be capable of changing the value of any SNVT in the LNS Database and any point available from a connected legacy system via the protocol driver to any legal value according to a schedule. A minimum of

200 user-definable schedules shall be supported and the specified scheduling functions shall be operator accessible and adjustable via graphics display. The graphics display shall include the following fields and functions:

a. Current date and time. The OS and M&C software shall automatically make Daylight Savings Time adjustments. Daylight savings time adjustment shall be capable of being disabled by the operator.

b. Building name and number.

c. System identifier and name.

d. System group. Systems shall be capable of being grouped by the user to perform according to a common schedule.

e. Weekly schedules. Each system shall have a weekly schedule based on a seven day per week schedule with independent schedules for each day of the week including no less than 6 value changes per day.

f. Holiday and special event schedules. System scheduling shall support holiday and special event calendar schedules independent of the daily schedule. Special event schedules shall include one-time events and recurring events. Scheduling of one-time events shall include the beginning and ending dates and times of the event. Holiday and special event schedules shall have precedence over device weekly schedules.

2.4.6.5 Alarms

The M&C software shall be capable of generating alarms and handling network variable inputs of type SNVT_Alarm from the control network. M&C Software shall be capable of handling and managing no less than 10,000 alarm points.

a. Alarm Data. Alarm data to be displayed and stored, as applicable and as specified, shall include:

(1) Identification of alarm including building, system (or sub-system), and device name.

(2) Date and time to the nearest second of occurrence.

(3) Alarm type:

(a) Unreliable: Indicates that the source device has failed due to the sensing device or alarm parameter being out-of-range or bad data.

(b) High Alarm.

(c) Low Alarm.

(4) Alarm set point and deadband(if analog).

(5) Engineering units.

(6) Current value or status of the alarm point.

(7) Alarm priority: There shall be two alarm priority levels; critical and informational. Critical alarms shall remain in alarm

until acknowledged by an operator and the alarm condition no longer exists; informational alarms shall remain in alarm until the alarm condition no longer exists or until the alarm is acknowledged.

(8) Alarm Message: A unique message with a field of 60 characters shall be provided for each alarm. Assignment of messages to an alarm shall be an operator editable function.

(9) Alarm Secondary Message: Secondary messages shall be assignable by the operator for printing to provide further information, such as telephone lists or maintenance functions, and shall be editable by the operator. The system shall provide for 100 secondary messages, each with 25 lines of 60 characters each.

(10) Acknowledgement status of the alarm and, where acknowledged, the time and date of acknowledgement.

(11) User who acknowledged the alarm.

b. Alarm Notification and Routing: The M&C software shall be capable of performing alarm notification and routing functions. Upon receipt or generation of an alarm the M&C software shall immediately perform alarm notification and routing according to an assigned routing for that alarm. The M&C software shall support at least 500 alarm routes; an alarm route shall be a unique combination of any of the following activities:

(1) Generate a pop-up up display on designated workstation monitors. The pop-up display shall include identification of the alarm, date and time of the alarm, alarm message, and current value/status of the alarm point. Alarms shall be capable of being acknowledged from the pop-up display by operators with sufficient permissions. Pop-up displays shall be displayed until acknowledged.

(2) Dial a numeric paging system and leaving a numeric message. The paging system number and numeric message shall be user configurable for each alarm route.

(3) Send an e-mail message via simple mail transfer protocol (SMTP; RFC 821). The e-mail shall contain a scripted message and all alarm data. The e-mail recipient and scripted message shall be user configurable for each alarm route.

(4) Print alarms to designated alarm printers. The printed message shall be the same as the pop-up message.

c. Alarm Display and Acknowledgement. The M&C software shall include an alarm display. A minimum of the most recent 100 system alarms shall be available for display at each workstation as shown, along with all associated alarm data. Alarms shall be capable of being acknowledged from this display. Multiple alarms shall be capable of being acknowledged using a single command. Operator acknowledgment of one alarm shall not automatically be considered as acknowledgment of any other alarm nor shall it inhibit reporting of subsequent alarms.

d. Alarm Storage and Reports: The M&C software shall store each alarm and its associated alarm data to hard disk. The stored data shall be

user-sortable and formatted for printing.

2.4.6.6 Trending

The M&C software shall be capable of performing real-time trending on a minimum of 5,000 points simultaneously with a minimum trending capacity of 100 points per second. The M&C software shall be capable of displaying and printing a graphical representation of each trend, and of multiple trended points on the same graph. The software shall be capable of saving trend logs to a file. If the file format is not plain ASCII text in a Comma-Separated-Value (CSV) format, the Contractor shall provide a means to export or convert the file to plain ASCII text in a CSV format. Each trend shall be user-configurable for:

a. Point to trend.

b. Sampling interval with a minimum sampling interval no greater than 1 second, and a maximum sampling interval no less than 1 hour.

c. Start and Stop Time of Trend: Start and stop times shall be determined by one or more of the following methods:

(1) Start Time and Stop Time

(2) Start Time and Duration

(3) Start Time and number of samples

2.4.6.7 Electrical Power Demand Limiting

The UMCS shall be able to monitor and limit the electrical demand using a demand limiting program, subject to the availability of appropriate data and control hardware. The demand limiting program shall operate continuously and shall execute at the M&C Software Server. It shall obtain electrical demand from the installation electric utility meters a minimum of once per minute and predict the electrical peak demand 30 minutes into the future. This predicted peak demand value shall be recalculated at a minimum of one (1) minute intervals. The Electrical Demand Target (EDT) and predicted demand shall be used by the demand limiting program to determine demand limit priority. The EDT shall be user configurable. When the actual demand exceeds the EDT a critical alarm shall be broadcast.

a. Demand limit priority level: The Demand limit priority level is a calculated value which is used by the M&C server to determine the group or groups of equipment to be shut off or set points adjusted (Chillers). Six (6) levels of demand priority (zero (0) through five (5)) shall be defined. When no loads are to be shut down the system shall be at demand limit level zero (0). When the predicted demand first exceeds the EDT, the demand limiting program shall designate the demand limit priority to have a value of 1. Successive levels of demand limit priority shall be based upon the amount (kW) that the predicted demand exceeds the EDT and duration of this excess. The minimum amount of time between changes to the demand limit priority level shall be operator-adjustable with a default value of 15 minutes.

b. Demand Limit Schedule and Monitoring Screen: The demand limit software shall use a spreadsheet type table which shall include the following information:

(1) Current demand, predicted demand

(2) Base-wide EDT

(3) Time of day

(4) For each system

(a) Equipment Description

(b) Equipment demand limit priority

(c) SNVT name used to override equipment occupancy mode (via the System Scheduler specified in Section 23 09 23: DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS) or to adjust chiller setpoint.

(d) Maximum off time

(e) Maximum shut-down or setpoint reset intervals per day

(f) Equipment status indicating current occupancy mode for non-chiller equipment and setpoint for chillers

This screen and associated table used for implementing the electrical power demand limiting algorithm shall have a user interface which allows the user to edit, add, and delete any item in the table.

c. Equipment shut down and chiller reset. Each mechanical system (air handler, chiller, fan coil unit, etc) shall have associated with it a demand limit priority from 0 to 5. A system with a priority of 5 shall never be shut down by the demand limiting program. Equipment whose demand limit priority is less than or equal to the base-wide demand limit priority level shall be shut down for a maximum time period of time as shown. Chillers shall have their setpoint reset or shall be shut down as shown. This shall be accomplished by setting the value of the Occupancy Override SNVT (to the System Scheduler)to OC_UNOCCUPIED or by adjusting the Chiller Setpoint via the Chiller Setpoint Override SNVT for the mechanical system as shown on the Demand Limit Schedule in a staged manner such that no less than 15 seconds elapses between changing any two SNVTs in a single building.

d. Equipment re-start: When predicted demand transitions from greater than the EDT to less than the EDT by the EDT Deadband value, the demand limit priority level shall be decremented and the appropriate equipment (equipment with a demand limit priority level greater than the base-wide demand limit priority) shall have their Occupancy Override SNVT (to the System Scheduler) set to OC_NUL. Chillers that have had setpoint reset shall have their setpoint override released or changed to a value appropriate for the new demand limit priority level. These SNVT changes shall be performed in a staged manner such that no less than 15 seconds elapses between changing any two SNVTS in a single building.

e. Manual initiation of demand limiting: The demand limiting program shall be configured to allow an operator to manually override the demand limit priority regardless of predicted demand. This override shall remain until manually released.

f. Program Inputs

(1) Calculated Equipment Demand Limit Priority Level (M&C Software Internal Value).

(2) Time-of-day

(3) Equipment maximum off time

(4) EDT (Electrical Demand Target)

(5) EDT Deadband

(6) Beginning and ending dates of winter and summer billing periods

(7) Length of sliding window interval

(8) Total demand

(9) Operating setpoint and occupancy status (current values)

(10) Beginning and ending dates for each billing cycle

g. Program Output.

(1) Occupancy Override SNVT (to System Scheduler) for each system

(2) Setpoint Override SNVT for each chiller with setpoint reset

(3) Predicted Demand

2.4.6.8 Demand Limiting with Real-Time Pricing

Demand Limiting with Real-Time Pricing shall perform Electrical Power Demand Limiting as specified except that demand limit priority shall be determined by real-time pricing data.

2.4.6.9 Programming Language

The M&C Software shall incorporate a programming (scripting) language for creating custom applications. Actions that shall be available through the programming language shall include the following functions:

a. Override SNVTs

b. Monitor SNVTs

c. Clock / Timer Functions

d. Math Functions: Addition, subtraction, multiplication, division, exponentiation, trigonometric and logarithmic functions.

e. Loops ("for" and "while")

f. Conditional Branches ("if-then-else")

g. Variable Define / Assignment / Use

h. Provide data to a graphic display

i. Get data from a graphic display

j. Initiate alarm conditions

k. Initiate Reports

l. Logic Functions: ("and", "or" and "not")

m. Bitwise logic functions.

n. User defined subroutines and functions.

2.4.6.10 Report Generation

Software shall be provided with commands to generate and format reports for displaying on current Workstation, printing, and storing on disk. Reports shall be stored by type, date, and time. The destination of each report shall be selectable by the operator. Dynamic operation of the system shall not be interrupted to generate a report. The report generation mode, either automatic or requested, shall be operator assignable. The report shall contain the time and date when the samples were taken, and the time and date when the report was generated. The software shall be capable of saving reports to a file. If the file format is not in a format compatible with the provided Office Automation Software, the Contractor shall provide a means to export or convert the file to a compatible format. Software shall be provided to format and store all data, trends, profiles, reports and logs specified herein in a comma-delimited text format to any media supported by the operating system. The software shall allow for automatic or manual generation of reports. For automatic reports the operator shall be able to specify the time the initial report is to be generated, the time interval between reports, end of period, and the output format for the report. The operator shall be able to modify, or inhibit a periodic report. Manual report generation shall allow for the operator to request at any time the output of any report. The software shall have a report generation utility capable of generating the following standard reports:

a. Electrical Power Usage Report: An electrical power Usage summary, operator selectable for substations, meters, or transducers, individual meters and transducers, any group of meters and transducers, and all meters for an operator selected time period. The report shall include the voltage, current, power factor, electrical demand, electrical power consumption, reactive power (Kvar) for each substation, facility, system or equipment as selected by the operator. The report shall be automatically printed at the end of each summary period and shall include:

(1) Total period consumption.

(2) Demand interval peak for the period, with time of occurrence.

(3) Energy consumption (kWh) over each demand interval.

(4) Time-of-use peak, semi-peak, off-peak, or baseline total kWh consumption.

(5) Reactive power during each demand interval.

(6) Power factor during each demand interval.

(7) Outside air (OA) temperature and relative humidity (RH) taken at the maximum and minimum of OA temperature of the report period with the time and dates of occurrence. At the installation's peak demand interval, the OA temperature and RH shall also be recorded.

(8) Calculated heating and cooling degree days based on a 65 degreesF balance point. Heating and cooling degree day balance point may be operator adjustable.

b. Electrical Peak Demand Prediction Report: A report based on the demand limiting program. The report shall include:

(1) Electrical Demand Target (EDT).

(2) Actual peak and predicted peak for each demand interval for that day.

(3) Predicted demand for the next demand interval.

c. Energy usage Report: An energy usage summary, operator selectable, for a unit, building, area, installation, and the entire UMCS. The report shall be divided by utility, and shall be capable of reporting on at least four separate utilities. The report shall include the following information:

(1) Beginning and ending dates and times.

(2) Total energy usage for each utility for the current and previous day.

(3) Total energy usage for each utility for the current and previous month.

(4) Maximum 15-minute interval average rate of consumption for each utility for the current and previous day and current and previous month.

(5) Outside air (OA) temperature and OA relative humidity (RH) or dew point for current and previous month and current and previous day:

(a) Average temperature and RH or dewpoint.

(b) Temperature and RH or dewpoint at maximum and minimum OA temperature with time and date of occurrence.

(b) Temperature and RH or dewpoint at maximum and minimum RH or dewpoint with time and date of occurrence.

(c) Temperature and RH or dew point at the installation's peak demand interval with the time and date of occurrence

(6) Calculated degree days.

d. Alarm Report: Outstanding alarms by building or unit, including time of occurrence.

e. Override Report: Points overridden, including time overridden, and identification of operator overriding the point.

f. Run Time Reports: A report totalizing the accumulated run time of individual pieces of equipment. The operator shall be able define equipment groupings and shall be able to generate reports based on these groupings.

g. Cooling Tower Profiles: A cooling tower profile for each cooling tower as shown, including:

(1) Total daily and monthly on-time (each fan).

(2) Number of on and off transitions (each fan).

(3) Maximum and minimum daily condenser water temperature and the time of occurrence for the current and previous months.

h. Chiller usage Report: A report of the operation of each chiller as shown on a daily and monthly basis, including:

(1) Daily run-time in each one of at least 10 discrete loading levels.

(2) Total on-time for each level for the current month.

(3) Monthly average energy use in kWh or Mbtu for total on-time at each level.

2.5 UNINTERRUPTIBLE POWER SUPPLY (UPS)

The uninterruptible power supply (UPS) shall be a self contained device suitable for installation and operation at the location of Server and Workstation hardware and shall be sized to provide a minimum of 20 minutes of operation of the connected hardware. Equipment connected to the UPS shall not be affected in any manner by a power outage of a duration less than the rated capacity of the UPS. UPS shall be complete with all necessary power supplies, transformers, batteries, and accessories and shall include visual indication of normal power operation, UPS operation, abnormal operation and visual and audible indication of AC input loss and low battery power. The UPS shall be UL 1778 approved. UPS powering Server Hardware shall support notification to the server via serial interface of impending battery failure.

2.6 RACKS AND ENCLOSURES

2.6.1 Enclosures

Enclosures shall meet the following minimum requirements:

a. Outdoors: Enclosures located outdoors shall meet NEMA 250 Type 4 requirements.

b. Mechanical and Electrical Rooms: Enclosures located in mechanical or electrical rooms shall meet NEMA 250 Type 2 requirements.

c. Other Locations: Enclosures in other locations including but not limited to occupied spaces, above ceilings, and plenum returns shall

meet NEMA 250 Type 1 requirements.

Enclosures supplied as an integral (pre-packaged) part of another product are acceptable.

2.6.2 Equipment Racks

Equipment racks shall be either aluminum or steel with bolted or welded construction. Steel equipment racks shall be painted with a flame-retardant paint. Guard rails shall be included with each equipment rack and have a copper grounding bar installed and grounded to the earth. These equipment racks shall be compatible with the electronic equipment provided.

2.7 FACTORY TEST

The Contractor shall perform factory testing of the UMCS as specified. The Contractor is responsible for providing personnel, equipment, instrumentation, and supplies necessary to perform required testing. Written notification of planned testing shall be given to the Government at least 21 days prior to testing, and in no case shall notice be given until after the Contractor has received written Government approval of the specific Factory Test Procedures. The Factory Test Procedures shall define the tests required to ensure that the system meets technical, operational, and performance specifications. The Procedures shall define location of tests, milestones for the tests, and identify simulation programs, equipment, personnel, facilities, and supplies required. The test procedures shall provide for testing all capabilities and functions specified and shown. The Procedures shall be developed from the design documentation, using the requirements of MIL-STD-2202 as a technical and format requirement. The Procedures shall cover actual equipment to be used by the Contractor for the specified project and shall consist of detailed instructions for test setup, execution, and evaluation of test results. Upon completion of the Factory Test, the Contractor shall prepare a Factory Test Report documenting the results of the Factory Test and submit it as specified.

PART 3 EXECUTION

3.1 EXISTING CONDITIONS SURVEY

The Contractor shall perform a field survey, including but not limited to testing and inspection of equipment to be part of the UMCS, and submit an Existing Conditions Report documenting the current status and its impact on the Contractor's ability to meet this specification. The Contractor shall verify the availability of the building network backbone at the BPOC location, and verify that the building network used CEA-709.1B.

3.2 DRAWINGS AND CALCULATIONS

3.2.1 Network Bandwidth Usage Calculations

The Contractor shall perform UMCS Network Bandwidth Usage Calculations for a normally loaded and a heavily loaded UMCS. Calculations shall be performed for network traffic at the M&C Server. A heavily loaded network is characterized as one performing the following activities simultaneously:

a. Trending a number of points equal to the specified minimum M&C software trending capacity at 15 minute intervals.

b. Trending (for loop tuning) 20 points at 2 second intervals.

c. Viewing 500 points via workstations with a 5 second update interval.

d. Transmitting load shed commands (via SNVTs) to 2,000 devices in a 1 minute interval.

e. Viewing of 10 system display graphic screens of 50 points each via browsers.

A normally loaded network is characterized as one performing the following activities simultaneously:

a. Trending 500 points equal at 15 minute intervals.

b. Viewing 100 points via workstations with a 5 second update interval.

c. Transmitting load shed commands (via SNVTs) to 200 devices in a 1 minute interval.

e. Viewing of 2 system display graphic screens of 50 points each via browsers.

3.2.2 UMCS Contractor Design Drawings

Contractor shall revise and update the Contract Drawings to include details of the system design. Drawings shall be on ISO A1 34 by 22 inches or A3 17 by 11 inches sheets. Details to be shown on the Design Drawing include:

a. Details on logical structure of the network. This includes logical location of all network hardware.

b. Manufacturer and model number for each piece of computer and network hardware.

c. Physical location for each piece of network or computer hardware.

3.2.3 As-Built Drawings

The Contractor shall prepare draft as-built drawings consisting of Points Schedule drawings for the entire UMCS and an updated Design Drawing including details of the actual installed system as it is at the conclusion of Start-Up and Start-Up Testing. In addition to the details shown in the design drawings, the as-built drawing shall include:

a. IP address(es) as applicable for each piece of network hardware.

b. IP address for each computer server, workstation and networked printer.

c. Network identifier (name) for each printer, computer server and computer workstation.

d. CEA-709.1B address (domain, subnet, node address) for each CEA-709.1B TP/FT-10 to IP Router.

Contractor shall prepare Draft As-Built Drawings upon the completion of Start-Up and Start-Up Testing and Final As-Built Drawings upon completion

of PVT Phase II.

3.3 INSTALLATION REQUIREMENTS

3.3.1 General

The Contractor shall install system components as shown and specified and in accordance with the manufacturer's instructions and shall provide necessary interconnections, services, and adjustments required for a complete and operable system. Communication equipment and cable grounding shall be installed as necessary to preclude ground loops, noise, and surges from adversely affecting system operation. Fiber Optic cables and wiring in exposed areas, including low voltage wiring but not including network cable in telecommunication closets, shall be installed in metallic raceways or EMT conduit as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.3.2 Isolation, Penetrations of Buildings and Clearance from Equipment

The UMCS shall be completely installed and ready for operation, as specified and shown. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exteriors shall be made watertight. Holes in concrete, brick, steel and wood walls shall be drilled or core drilled with proper equipment; conduits installed through openings shall be sealed with materials which are compatible with existing materials. Openings shall be sealed with materials which meet the requirements of NFPA 70 and SECTION 07 84 00 FIRESTOPPING.

3.4 INSTALLATION OF EQUIPMENT

3.4.1 Wire and Cable Installation

System components and appurtenances shall be installed in accordance with NFPA 70, manufacturer's instructions and as shown. Necessary interconnections, services, and adjustments required for a complete and operable signal distribution system shall be provided. Components shall be labeled in accordance with TIA/EIA-606-A. Penetrations in fire-rated construction shall be firestopped in accordance with Section 07 84 00 FIRESTOPPING. Conduits, outlets and raceways shall be installed in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Wiring shall be installed in accordance with TIA/EIA-568-B.1 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Wiring, and terminal blocks and outlets shall be marked in accordance with TIA/EIA-606-A. Non fiber-optic cables shall not be installed in the same cable tray, utility pole compartment, or floor trench compartment with ac power cables. Cables not installed in conduit or raceways shall be properly secured and neat in appearance.

3.4.2 Grounding

Signal distribution system ground shall be installed in accordance with TIA J-STD-607-A and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Equipment racks shall be connected to the electrical safety ground.

3.4.3 Power-Line Surge Protection

Equipment connected to ac circuits shall be protected against or withstand power-line surges. Equipment protection shall meet the requirements of

IEEE C62.41.1, IEEE C62.41.2. Fuses shall not be used for surge protection.

3.4.4 Computer Hardware and Software

3.4.4.1 Hardware Installation

Computer Hardware shall be installed as shown. Computer Servers shall be powered through a UPS, and shall be installed and configured such that the server will automatically undergo a clean shutdown upon low battery signal from the UPS.

3.4.4.2 Software Installation

Contractor shall install software as follows:

a. Operating system: The Contractor shall install the OS on each Server and Workstation and configure user names and passwords.

b. Office Automation Software: The Contractor shall install the office automation software on each server and workstation.

c. Virus Protection software: The Contractor shall install the virus protection software on each server and workstation and shall configure weekly virus scans.

d. CEA-852-A Configuration Server: The Contractor shall install and configure one CEA-852-A Configuration Server. The CEA-852-A Configuration Server may be installed on Server Hardware, Workstation Hardware, or an CEA-709.1B TP/FT-10 to IP Router.

e. CEA-709.1B Network Configuration Tool: The Contractor shall install the network configuration tool software as shown. The server version of the software shall be installed on server hardware, and client versions shall be installed on workstation or server hardware.

f. Monitoring and Control Software: The Contractor shall install the monitoring and control software as shown. The server version of the software shall be installed on server hardware, and client versions shall be installed on workstation or server hardware.

3.4.5 Network Hardware

The Contractor shall install all network hardware in an enclosure or a telecommunication closet as defined by the project site. IP Network Hardware shall be powered through a UPS.

3.4.6 IP Addresses

For equipment requiring IP addresses, the Contractor shall coordinate with the DOIM to obtain IP addresses.

3.4.7 IP Network Installation

The Contractor shall install the IP Network in accordance with the following:

a. Determine requirements for and install interior copper LAN cable in accordance with Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM as needed to meet contract requirements.

b. Determine requirements for and install interior fiber optic cable in accordance with Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM as needed to meet contract requirements.

c. All exterior cable shall be buried. When installing fiber, Contractor shall provide at least 6 pairs of fiber.

d. Determine requirements for and install Network Hardware as shown and as needed to meet contract requirements.

3.5 INTEGRATION OF BUILDING LEVEL CONTROLS

3.5.1 Integration of CEA-709.1B Systems

The Contractor shall perform the following tasks (per Section 23 09 23) to integrate the building system into the UMCS:

a. If the building control network contains an IP backbone, install and configure an IP router or Ethernet switch to connect the building IP network backbone to the UMCS IP Network. Re-configure CEA-709.1B TP/FT-10 to IP Routers in the building to use the UMCS CEA-852-A Configuration Server. Otherwise, install and configure an CEA-709.1B TP/FT-10 to IP Router to connect the building level TP/FT-10 network backbone to the UMCS IP Network.

b. Update the UMCS LNS Database and update UMCS Network representation (drawings) in the Network Configuration Tool. The LNS database shall be updated by merging the building database with the UMCS database. In cases where the building database is not available the Contractor shall use the Network Configuration Tool software to discover the building network and create an LNS Database for the building and then merge the building database and the UMCS database.

d. Establish network variable bindings as shown and as necessary to support M&C Software functionality:

(1) SNVTs used for display on currently active displays shall be updated (via polling) as necessary to meet display requirements.

(2) SNVTs used for currently active trends shall be updated (via polling) as necessary to meet trend interval requirements.

(3) Alarm SNVTs shall be bound from the device originating the alarm to the M&C Software. Alarms shall be bound shall use the acknowledged service.

(4) SNVTs used for scheduling shall be bound to the appropriate System Scheduler with a maximum send time (minimum time between subsequent transmissions of the SNVT) of 45 minutes, shall be of type SNVT_occupancy, and support the following values: OC_OCCUPIED, OC_UNOCCUPIED and OC_STANDBY.

(5) SNVTs used for overrides shall be polled to the device receiving the override. SNVTs for overriding schedules (via the System Scheduler) shall be of type SNVT_occupancy and shall support the following values: OC_OCCUPIED, OC_UNOCCUPIED, OC_STANDBY and OC_NUL. SNVTs used to override schedules or setpoints for Demand Limiting functions shall use the acknowledged

service.

e. Configure M&C Software functionality:

(1) Create graphical pages for System Graphic Displays, including overrides, as shown on the Points Schedule and as specified. SNVTs for monitoring shall be updated while the monitoring graphic for that SNVT is active.

(2) Configure alarm handling as shown on the Points Schedule and Alarm Routing Schedules and as specified.

(3) Configure the scheduling function of the M&C software to schedule systems (SNVTs) as shown on the Points Schedule and as specified. Label schedules and scheduled points with full English-language descriptors. For scheduling and schedule overrides (including Demand Limiting), SNVT values of OC_OCCUPIED correspond to the system operating in occupied mode, OC_UNOCCUPIED corresponds to unoccupied mode and OC_STANDBY corresponds to Warm-Up-Cool-Down mode. For overrides, OC_NUL corresponds to a no override (and is used to release an override).

(4) Create trends for required points as shown on the Points Schedule and as specified. Trend points at 15 minute intervals.

(5) Configure Demand Limiting as shown on the Demand Limit Schedule and Points Schedule and as specified.

3.5.2 Integration of Legacy CEA-709.1B Systems

The Contractor shall perform all tasks (not per Section 23 09 23) required to integrate a CEA-709.1B System installed per Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS.

3.5.3 Integration of Legacy non-CEA-709.1B Systems at Building via Gateway

When integrating a non-CEA-709.1B Legacy system using a CEA-709.1B Gateway the Contractor shall perform the following tasks:

a. Install and configure the CEA-709.1B Gateway, including adding the gateway to the LNS database and network drawing. The gateway shall be configured such that the required data (points) as shown from the Legacy system can be read as SNVTs on the CEA-709.1B side of the gateway and that required commands as shown on the legacy side of the gateway can be written as SNVTs on the CEA-709.1B side of the gateway.

b. When the Gateway performs protocol translation to CEA-709.1B, an CEA-709.1B TP/FT-10 to IP Router shall be installed on configured to connect the gateway to the UMCS IP Network.

c. Establish network variable bindings for all alarms as shown.

d. Configure M&C functionality as specified in paragraph Integration of CEA-709.1B (per Section 23 09 23) Systems.

3.5.4 Integration of Legacy non-CEA-709.1B Systems at M&C Server via Protocol Driver

When integrating non-CEA-709.1B legacy systems at the M&C Server the

Contractor shall:

a. Extend the legacy system network to the M&C Server

b. Configure the M&C software protocol driver to provide read and write access to required legacy system data as shown.

c. Configure M&C functionality as specified in paragraph Integration of CEA-709.1B (per Section 23 09 23) Systems

3.6 START-UP AND START-UP TESTING

Contractor shall test all equipment and perform all other tests necessary to ensure the system is installed and functioning as specified. Contractor shall prepare a Start-Up and Start-Up Testing Report documenting all tests performed and their results and certifying that the system meets the requirements specified in the contract documents.

3.7 PERFORMANCE VERIFICATION TEST (PVT)

3.7.1 PVT Phase I Procedures

PVT Procedures shall include:

a. Network bandwidth usage and available bandwidth (throughput)measurements. Network bandwidth usage shall reference the normal usage network Bandwidth Calculations.

b. Test System Reaction during PVT: Under system normal heavy load {as defined in paragraph Bandwidth Usage Calculation), no more than 10 seconds shall lapse from the time an alarm is generated at a node until the M&C software provides notification and the alarm is displayed. The total system response time from initiation of a control action command from the workstation, to display of the resulting status change on the workstation shall not exceed 20 seconds under system normal heavy load conditions assuming a zero response time for operation of the node's control device.

c. Verification of IP Connectivity.

d. Verification of configuration of M&C Software functionality.

3.7.2 PVT Phase I

The Contractor shall demonstrate compliance of the control system with the contract documents. Using test plans and procedures previously approved by the Government, the Contractor shall demonstrate all physical and functional requirements of the project. Upon completion of PVT Phase I and as specified the Contractor shall prepare and submit the PVT Phase I Report documenting all tests performed during the PVT and their results. The PVT report shall include all tests in the PVT Procedures and any other testing performed during the PVT. Failures and repairs shall be documented with test results.

3.7.3 PVT Phase II

PVT Phase II shall consist of Basic Operator Training. Failures or deficiencies of the UMCS during Basic Operator Training shall be considered PVT failures. Upon completion of PVT Phase II and as specified the

Contractor shall prepare and submit the PVT Phase II Report documenting any failures which occurred and repairs performed during PVT Phase II.

3.8 TRAINING

The Contractor shall conduct training courses for designated personnel in the maintenance, service, and operation of the system as specified, including specified hardware and software. The training shall be oriented to the specific system provided under this contract. The Contractor is responsible for providing audiovisual equipment and other training material and supplies. When training is conducted at Government facilities, the Government reserves the right to videotape the training sessions for later use. A training day is defined as 8 hours of classroom instruction, excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility. For guidance in planning the required instruction, the Contractor should assume that attendees will be tradesmen such as electricians or boiler operators. Approval of the Contractor's training schedule shall be obtained from the Government at least 30 days prior to the first day of training.

3.8.1 Training Documentation

The Contractor shall prepare training documentation for each course. Basic Operator Training Documentation, Advanced Operator Training Documentation, and Operator Refresher Training Documentation shall each consist of:

a. Course attendance list: A list of course attendees shall be developed in coordination with and signed by the Controls, HVAC, Electrical shop supervisor.

b. Training Manuals: Training manuals shall include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. Where the Contractor presents portions of the course material by audiovisuals, copies of those audiovisuals shall be delivered to the Government as a part of the printed training manuals.

3.8.2 Basic Operator Training

The Basic Operator Training course shall be taught at the project site on the installed system for a period of no less than 5 training days during Phase 2 of the PVT. A maximum of ten personnel will attend this course. This training shall be targeted towards training personnel in the day-to-day operation and basic maintenance of the system. Upon completion of this course, each student, using appropriate documentation, should be able to start the system, operate the system, recover the system after a failure, perform routine maintenance and describe the specific hardware architecture and operation of the system. This course shall at a minimum include:

a. General system architecture.

b. Functional operation of the system, including workstations and system navigation.

c. System start-up procedures.

d. Failure recovery procedures.

e. Schedule configuration.

f. Trend configuration.

g. Perform point overrides and override release.

h. Reports generation.

h. Alarm reporting and acknowledgements.

j. Diagnostics.

k. Historical files.

l. Maintenance procedures:

(1) Physical layout of each piece of hardware.

(2) Troubleshooting and diagnostic procedures.

(3) Preventive maintenance procedures and schedules.

3.8.3 Advanced Operator Training

The advanced operator course shall be taught at the project site for a period of not less then five days. A maximum of ten personnel will attend this course. The course shall consist of "hands-on" training under the constant monitoring of the instructor. The instructor shall be responsible for determining the appropriate password to be issued to the student commensurate with each student's acquired skills at the beginning of each of these individual training sessions. Advanced Operator Training shall include training on the M&C Software and the CEA-709.1B Network Configuration Tool. Upon completion of this course, the students should be fully proficient in the operation and management of all system operations. The Contractor shall report the skill level of each student at the end of this course. This course shall at minimum include:

a. A review of all topics in Basic Operator Training

b. CEA-709.1B 1 Network Management

c. M&C Software Graphic Generation

d. M&C Software Application Programming (M&C Software Programming Language)

e. System Administrator including Operating System maintenance, passwords, networking, firewalls and anti-virus software

3.8.4 Operator Refresher Training

The refresher course shall be taught at the project site for a period of two training days when approved by the Government and as specified in paragraph PROJECT SEQUENCING. A maximum of ten personnel will attend the course. The course shall be structured to address specific topics that the students need to discuss and to answer questions concerning the operation of the system. Upon completion of the course, the students should be fully proficient in system operation and have no unanswered questions regarding operation of the installed UMCS. Any system failures discovered during the Operator Refresher Training shall be corrected by the Contractor at no cost

to the Government.

APPENDIX A

QC CHECKLIST

This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such.

This checklist is for (check one:)

Pre-Construction QC Checklist Submittal (Items 1-3) |____|

Post-Construction QC Checklist Submittal (Items 1-6) |____|

Close-out QC Checklist Submittal (Items 1-14) |____|

Initial each item in the space provided (|____|) verifying that requirement has been met.

Items verified for Pre-Construction, Post-Construction and Closeout QC Checklists Submittal:

1 Network bandwidth calculations have been performed and indicate that the UMCS will meet network bandwidth requirements. |____|

2 Contractor Design Drawing Riser Diagram includes location and types of Building Point Of Connection (BPOC) Hardware. |____|

3 M&C Software is LonWorks Network Services (LNS) based and uses LNS for interfacing to CEA-709.1B networks. |____|

Items verified for Post-Construction and Closeout QC Checklist Submittal:

4 Connections between the UMCS IP network and CEA-709.1B building networks are through CEA-709.1B TP/FT-10 to IP Routers, IP Routers or Ethernet Switches |____|

5 Computer workstations and servers are installed as shown on the UMCS Riser Diagram. |____|

6 Training schedule and course attendee lists have been developed and coordinated with shops and submitted. |____|

Items verified for Closeout QC Checklists Submittal:

7 LNS Database is up-to-date and accurately represents the final installed system |____|

8 All software has been licensed to the Government |____|

9 M&C software monitoring displays have been created for all building systems, including all override and display points indicated on Points Schedule drawings. |____|

10 Final As-built Drawings accurately represent the final installed system. |____|

QC CHECKLIST

11	Default trends have been set up (per Points Schedule drawings)	|____|
12	M&C Software schedules have been set up (per Occupancy Schedule drawing).	|____|
13	O&M Instructions have been completed and submitted.	|____|
14	Basic Operator and Advanced Operator Training courses have been completed	|____|

_____

(QC Representative Signature) (Date)

-- End of Section --